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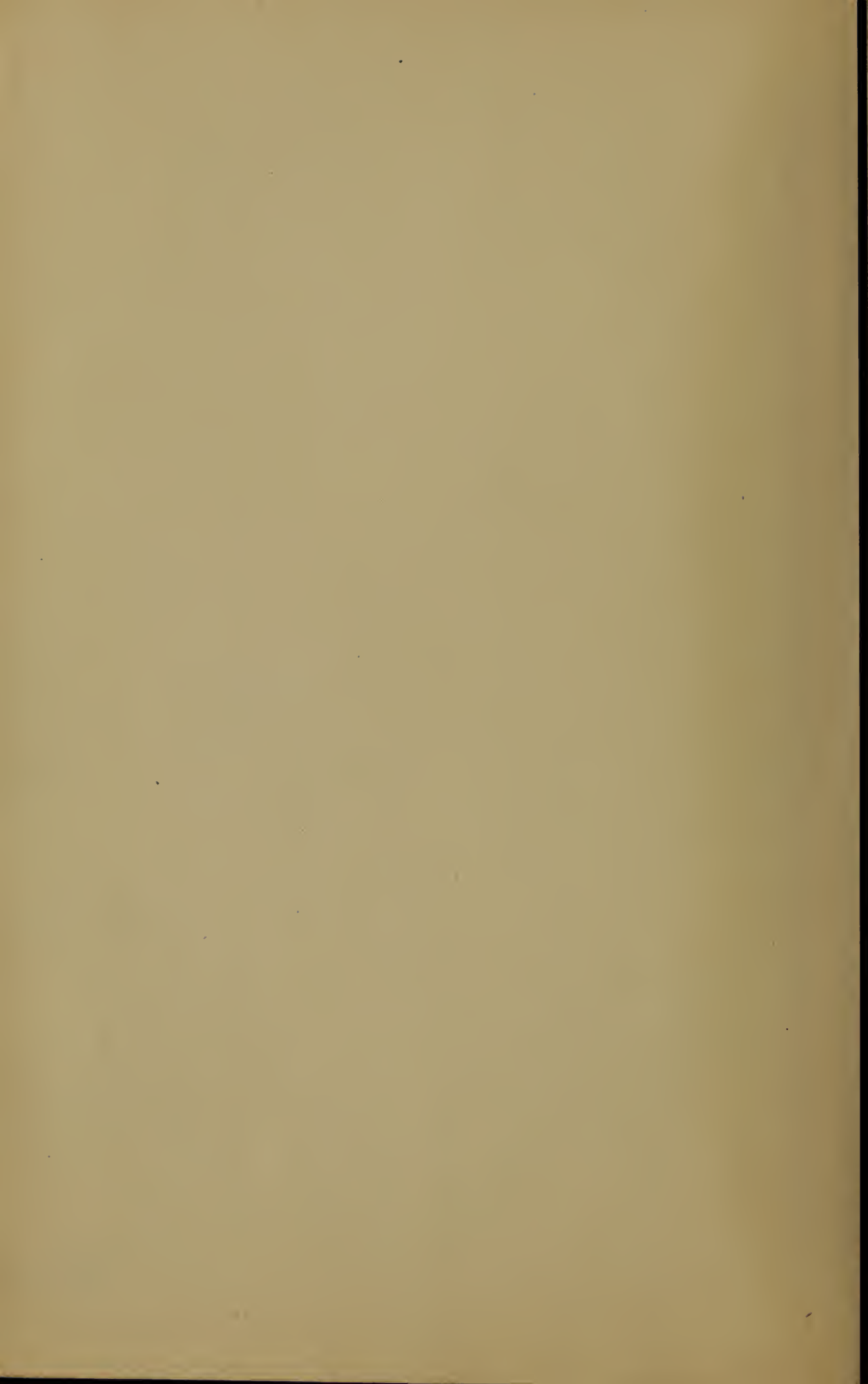
NUMBER 23
OCCASIONAL PAPERS
ENGINEER SCHOOL
UNITED STATES ARMY

EXTRACTS

FROM

Reports Upon Technical Details of Engineering Works 1906

WASHINGTON BARRACKS, D. C.
PRESS OF THE ENGINEER SCHOOL
1907



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DEFENSES OF THE COAST OF MAINE AND NEW HAMPSHIRE.

(Officer in charge, Lieut. Col. W. M. Black, Corps of Engineers.)

The construction methods detailed in the technical report for 1905 for the traverse roofs of the 6-inch batteries have proved satisfactory. The only improvement made has been a provision for channel iron gutters in recesses in the magazine ceilings directly beneath the planes of weakness of the roof blocks. The exposed surfaces of all concrete blocks are now finished with the wood float only. When surfaces are trowelled smooth, a skin of cement is brought to the top. This has a larger coefficient of expansion than the concrete, and a network of disfiguring hair cracks is formed on the surface. Under certain conditions this skin may flake off.

The waterproof pavements for the loading platforms described in page 3006 have proved satisfactory to date. When soft burned porous tile are kept saturated with water and exposed to alternate freezing and thawing under the severe conditions of the Maine climate, they are broken up. In the latest work, tile laid in positions subject to such exposure have been boiled in paraffine before placing. Each tile thus treated took up about one-half pound of paraffine, and subsequent tests showed that the treated tiles had become non-absorbent.

In some of the older batteries the mass concrete of the traverses and parapets is very porous. In these cases annoying leaks are sometimes formed in the galleries below the waterproof pavements by water from the porous concrete entering the gallery roof supporting the pavement where this abuts against the mass. The water enters below the waterproofing and follows along the sides of the supporting I-beams for some distance before appearing on the surface. The conditions have been helped by a narrow groove cut from below into the ceiling, outside of the mass and parallel to its face. This intercepts a part of the water, but to stop the leak the water must be kept out of the concrete masses. Experiments looking to this end have been fairly successful.

Waterproofing Exterior Surfaces.—In one of the older batteries the galleries in the traverse were very wet. A coat of Staso cement applied on the surface, in conjunction with the Staso compound in the larger cracks, which were widened to receive it, made a decided improvement. The

amount of surface covered was insufficient to stop all leaks, and further work remains to be done.

In another battery, where expansion cracks had formed in the loading platform and caused leaks in the galleries beneath, half-inch expansion joints were formed 10 feet apart and filled with the elastic Staso compound, and the smaller intermediate cracks were filled with the non-elastic glycerine and litharge cement. This was also fairly successful. This cement bonds strongly with the concrete.

Coal tar pitch applied with a brush while melted was also tried successfully on the top of the traverses, in the same manner as in the New York district. The black color of the coal tar pitch and the red color of the Staso are disadvantageous, in making the superior slopes more conspicuous as seen from the sea.

Another leaking traverse was treated on its top surface with paraffine after the larger cracks had been filled with Webster's cement. A mixture of 1 part white paraffine wax and 2 parts kerosene heated to a temperature of 212° was applied to the surface with a brush. The mixture cooled at once and left a thin skin on the surface of the concrete. This was then gone over with a hot smoothing iron, such as is used for asphalt pavements, and the paraffine largely disappeared into the concrete. Eighty-eight pounds of paraffine were used on 2,400 square feet of surface at a cost of \$0.014 per square foot. The work was done in November, 1905, and resulted in a great reduction of the leakage into the traverse rooms. Another application of the paraffine being made now seems to show that the coat applied last fall has penetrated the concrete sufficiently to permit the absorption of more paraffine. The application of the paraffine darkens the color to that of wet concrete.

Elaterite cement paint, manufactured by the Elaterite Paint and Manufacturing Co., of Des Moines, Iowa, has been given a short test on the surface of a leaky gutter sunk in the top of a traverse. It spreads thinly on the concrete, adheres strongly to it and renders it waterproof. Should it stand the test of time it is a very valuable waterproofing material. Its color is black.

A mixture by volume of 3 parts litharge, 1 part glycerine, 48 parts Portland cement and 48 parts sand, makes a strongly adherent and dense plaster, which has been used with some success in the ceiling of a leaky traverse room, through which water had been percolating freely. A groove cut in the ceiling in the side from which the greater part of the water apparently came afforded a drain, and the plaster coat prevented the general percolation through the ceiling. The plaster bonded well with

the concrete without other aid than cleaning the surface with a wire brush. It has been in too short a time to be tested thoroughly.

In one of the mortar batteries a stone filling had been placed under the loading platform, without adequate drainage. This filling formed a reservoir for water which froze in the winter and raised the blocks of the pavement, which in summer fell back into place. A series of holes was drilled through the pavement during the past summer and cement grout was forced in by gravity. Levels taken during the past winter showed a marked improvement. Further treatment of the same kind will be made during the present season.

The office test of sheet copper reported on page 3004 of the annual report of the Chief of Engineers for 1905 was continued until July 14, 1906. The copper in box form was removed from its supporting wood cover, emptied and cleaned. The bottom of the box was bright and clean. Toward the top of the sand and above it the copper was heavily coated with the green and bluish salts. The back of the plate, where in contact with the wet wood of the cover, was also heavily coated and pitted half way through, the pits being filled with red copper oxide. On weighing the copper it was found to have lost 2.04 per centum in weight. The plate suspended in air was heavily coated with the greenish salts. After cleaning, it was found to have lost 6.8 per centum of its weight.

Auxiliary Buildings.—Several buildings pertaining to the mine defense have been constructed during the year, with steel or wood frames covered and lined with cement plaster reinforced with expanded metal. The frames of these buildings are constructed in the usual manner, excepting that the studding is spaced 12 inches center to center. On the studding is stretched (with staples for wood and by wiring for steel) expanded metal (No. 18, one-half inch mesh) which with wood studding is furred out by one-quarter inch steel rods. Between the studding and one-half to three-quarters of an inch in rear of the expanded metal, boards are set up temporarily, filling the spaces. The plaster coat is then placed and pressed well in against the boards, working from the bottom up. This is placed in two coats, the second being placed as soon as the first coat has begun to set, but before it has set enough to form a plane of weakness. The finish is given with a wood float. The total thickness of the plaster is made about 2 inches. After the plaster is set, the boards are removed and any imperfections in the back of the slab are filled. Parker's metal corner strips are used in exterior corners. The plaster is composed of 1 part lime putty of the consistency of thick cream (the lime having been slaked and the putty made ten days before time for using), 3 parts cement, and 8 parts sand. No hair is used. The plaster must be mixed

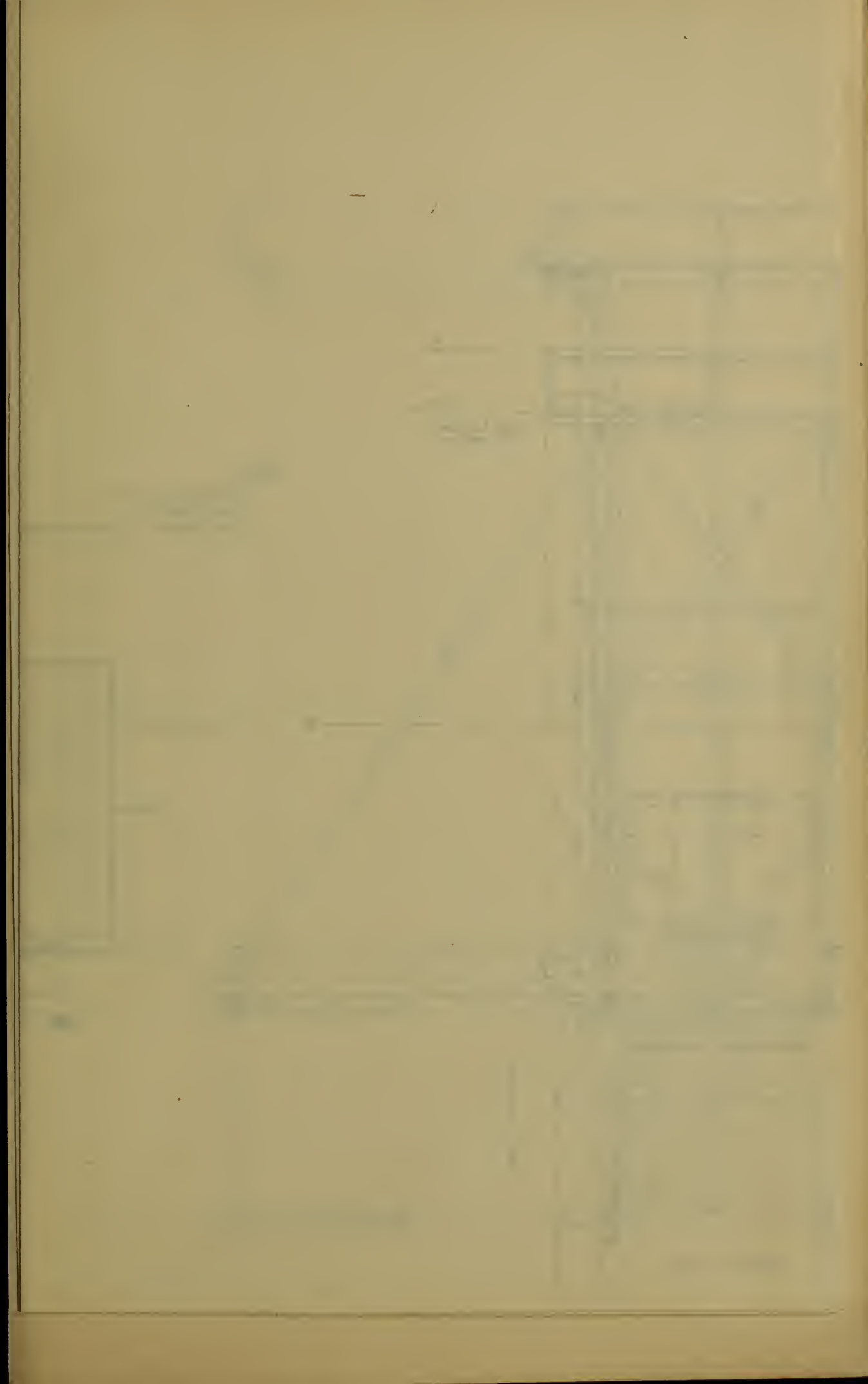
rather stiff. When set, this plaster is hard and dense and has withstood the winter without injury. To form a backing for the inside plaster, a heavy, reasonably waterproof building paper (like 3-ply Raven) is placed in the studding and expanded metal (B lath) is stretched over this. The inside slab is made about 1 inch thickness. A small quantity of calcium plaster was added to the cement plaster for ceiling work and for running cornice and mouldings. All hollow spaces in the walls and ceilings must be connected with the air outside or within the building by holes through the plaster, to lessen the strain on the plaster slabs caused by the air pressure produced by the blasts of the guns. Observations made during target practice show a marked air movement through the holes when the guns are fired.

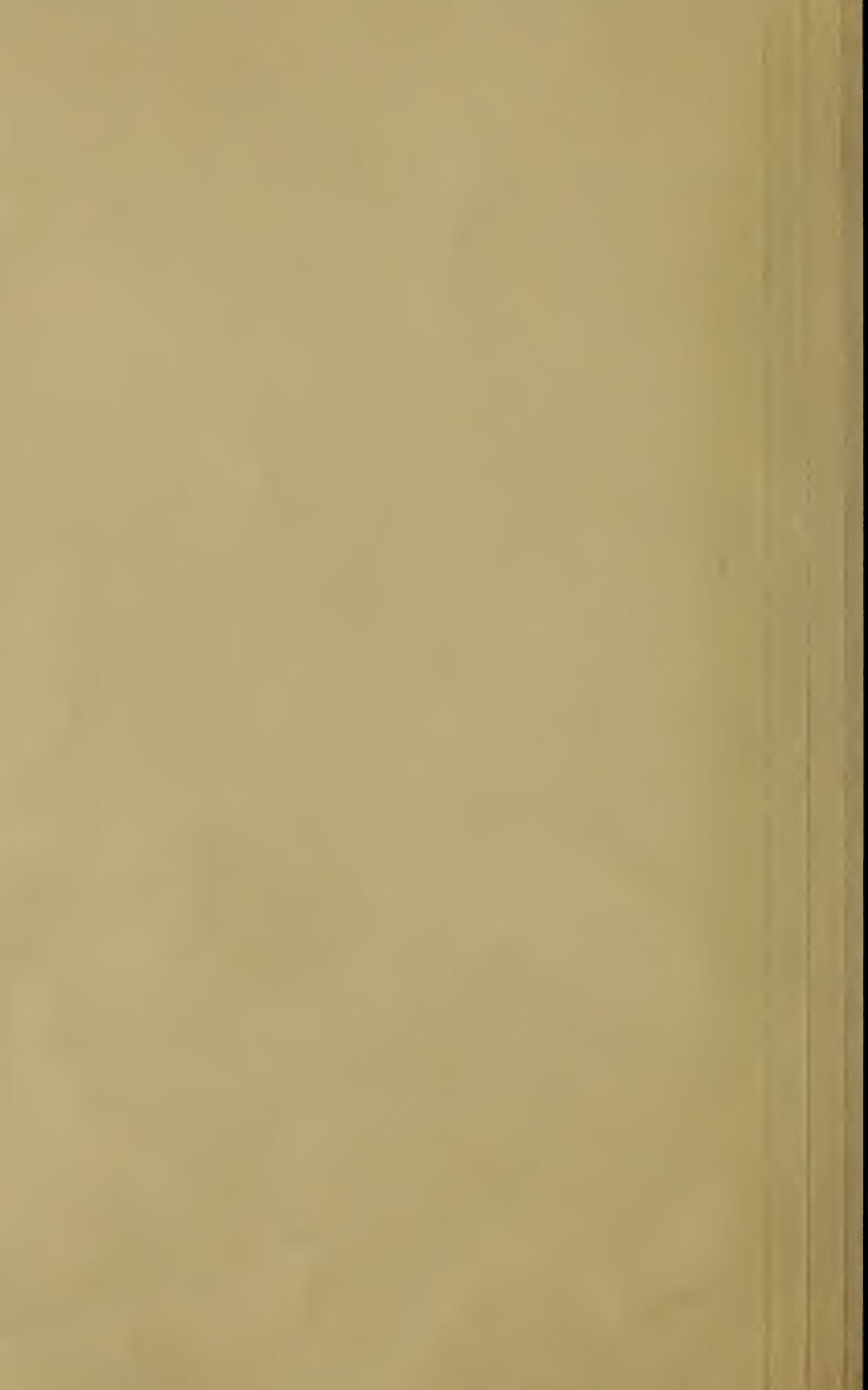
In two of the buildings the roofs were made of reinforced concrete slabs made like the outside sheathing, 2 to 3 inches thick, running from the ridge to the eaves, and provided with expansion joints. These roofs have been in place for about nine months and are tight.

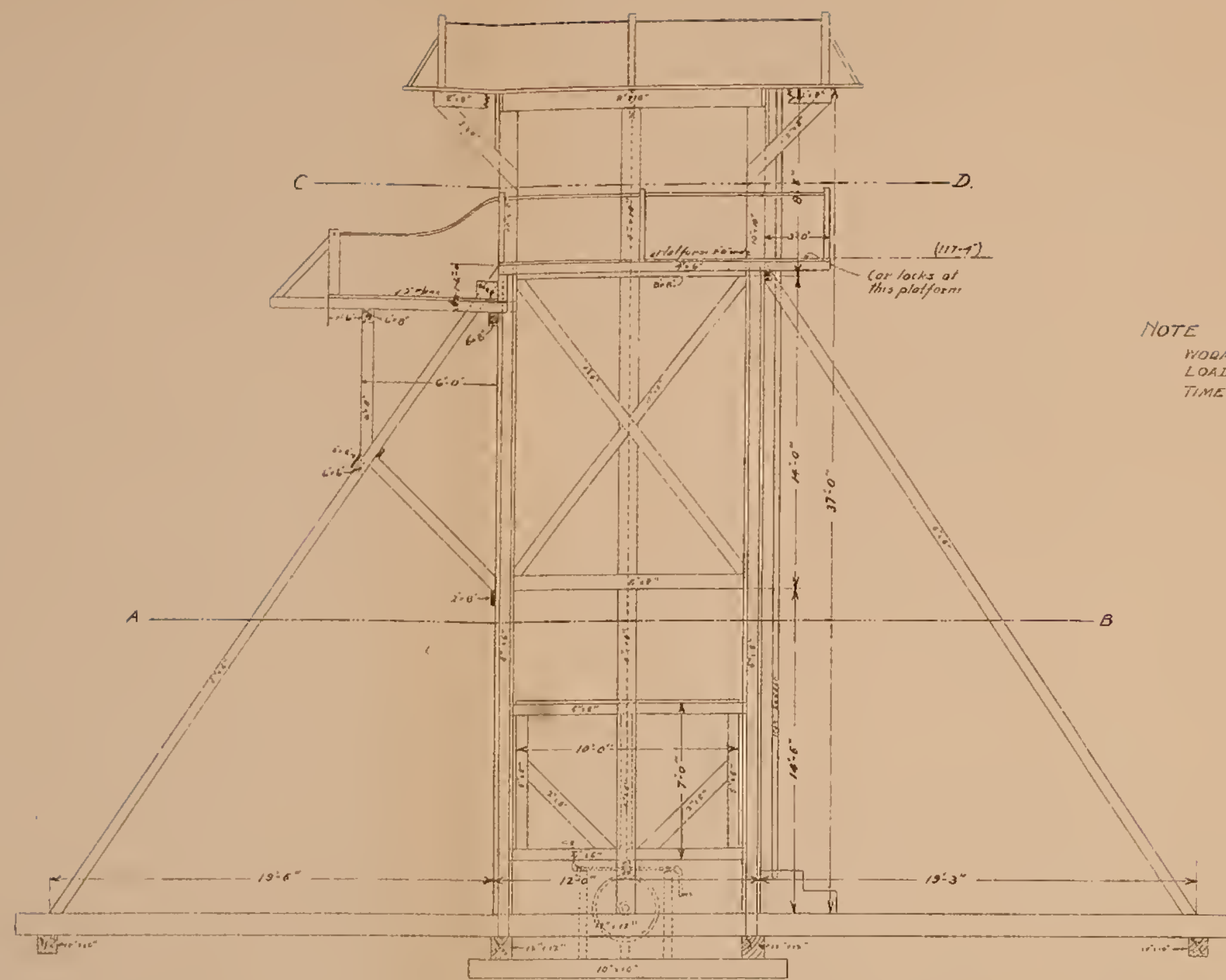
A tin roof was used in a double observation station. For sound deadening a layer of "Florian" sound-deadening felt and one layer of "National" deadening felt were placed between the tin and the roof sheathing. This combination seems efficacious.

The water fixtures for the closets and wash-bowls of the auxiliary buildings are of the non-freezing type, with automatic drainage. The faucets of the wash-bowls are operated by pedals in the floor. All valves and traps are placed below the frost line in a small cement vault, which can be filled in winter with fresh horse manure.

Owing to the conditions at Portland, the search lights of the forts have to be elevated. They are placed on towers in the rear of the line of observation stations and are elevated sufficiently to prevent the illumination of the batteries in the foreground. In one of the forts, where the available site is restricted, the 36-inch observing light is mounted on the same tower as the 60-inch search light and is 13 feet below it. This arrangement is satisfactory. It is easy to prevent the beams from crossing, and also to prevent the lights from blanketing the observers in the stations and in the batteries. The tower is of temporary character and built as shown in the accompanying sketch. The 60-inch light is on a platform, raised and lowered by a hand winch.

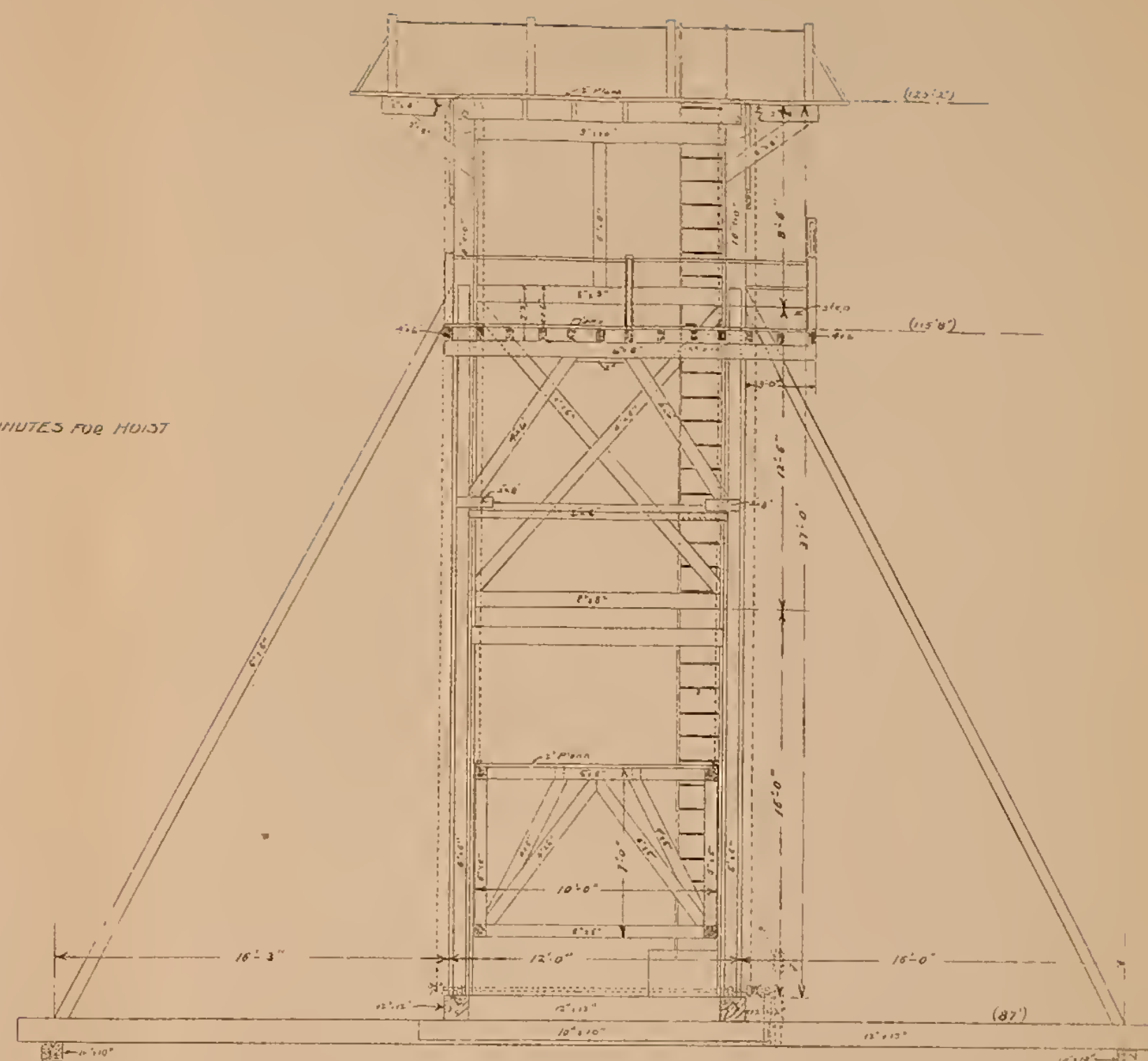




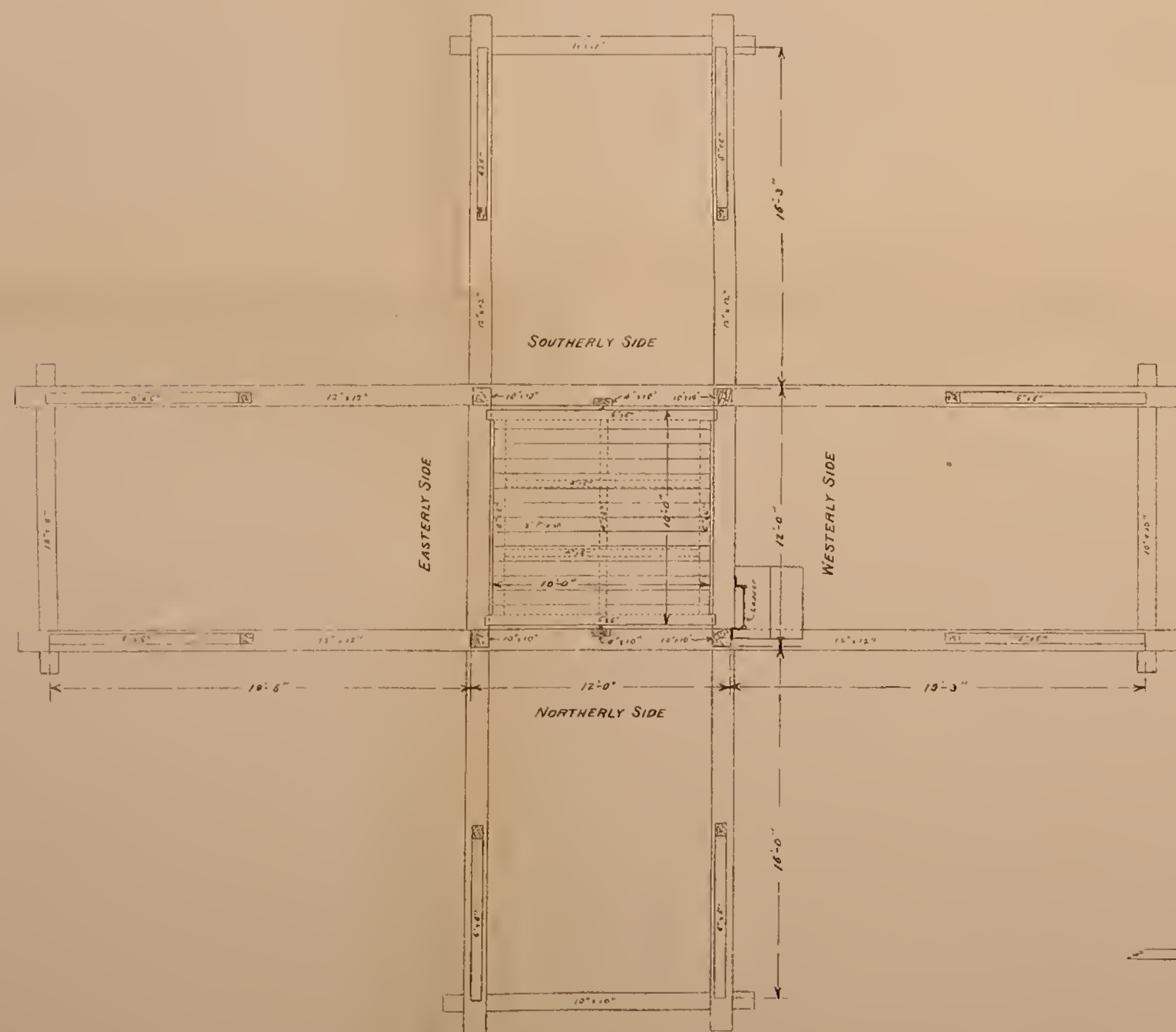


NORTHERLY ELEVATION

NOTE
WOOD GEAR HOIST
LOAD 5000 lbs
TIME ABOUT 15 MINUTES FOR HOIST



EASTERLY ELEVATION



HORIZONTAL SECTION ON A-B

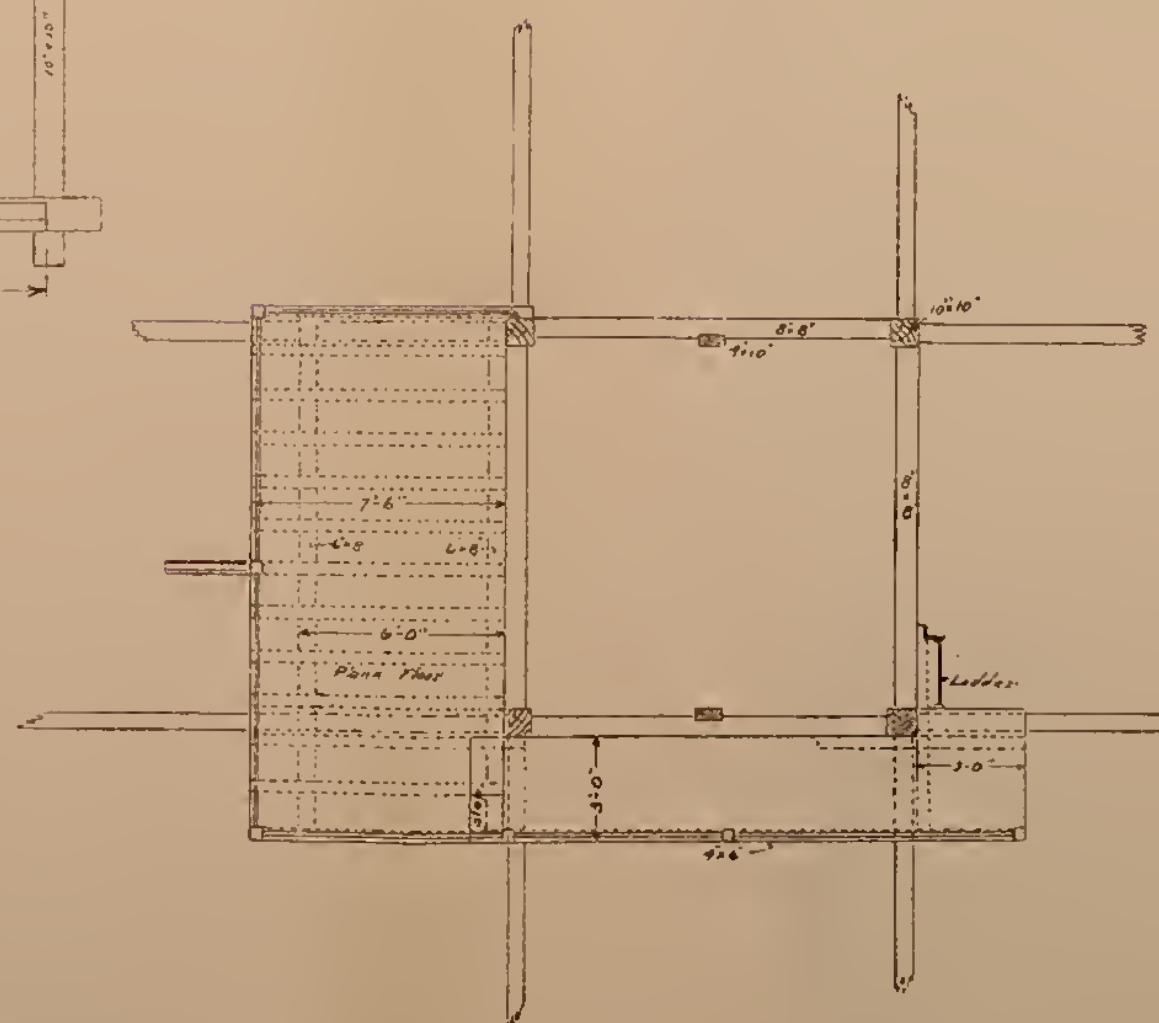
FORT WILLIAMS, ME.
TEMPORARY SEARCHLIGHT TOWER-TIMBER

Scale: $\frac{1}{4}''=1'$

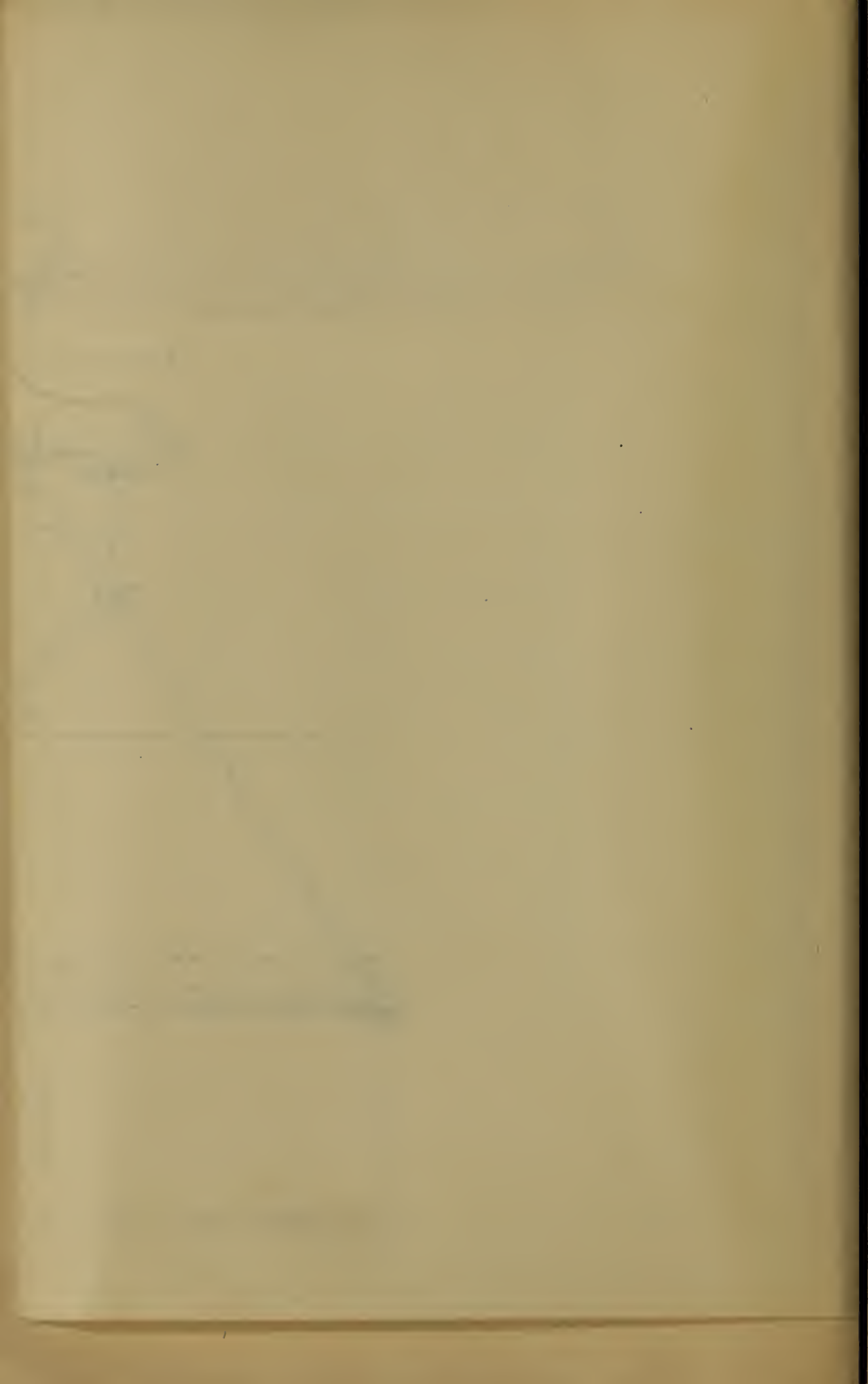


U.S. Engineer Office,
Portland, Me. July 20, 1906

W. W. Rank
Lieut. Col. Corps of Engineers.



HORIZONTAL SECTION ON C-D.



DEFENSES AT EASTERN ENTRANCE TO LONG ISLAND SOUND.

(Officer in charge, Lieut. Col. C. F. Powell, Corps of Engineers.)

PREVENTION OF LEAKAGE AT EMPLACEMENT ROOMS.

Sheet copper waterproof course, as described in my technical report for 1903, annual report, Chief of Engineers, page 2388, has so far given satisfaction.

WATERPROOF COATINGS AND SEAM FILLERS.

Observations and further experiments with working samples of such material as mentioned in technical report for 1904, annual report of the Chief of Engineers, page 3718, and in Eighth Supplement to Mimeograph 61, were continued. The coating of Elliot's Roof Leak on concrete superior slopes, which appeared to be excellent for several months, begun to scale under wear after a year. A new sample of Hydrolene B, melting point 200° , and Staso liquid cement, applied March, 1905, on cold surfaces, wear well to the present time; the sanded better than the unsanded parts. Each penetrates and adheres to the concrete. Staso has an Indian red color fading on exposure; Hydrolene B has a fast black color. Nicolite No. 1 and No. 2, and Szerelmey did not appear so suitable. Linseed oil waterproofing, described in the report of Chief of Engineers named above, has been extensively used in this district and is regarded favorably.

Staso Compound No. 5 was placed in a vertical joint 1 inch wide and 2 inches deep, March 14, and in horizontal joints February 2, 1905. It showed a tendency to run in warm weather and bulge out of the joint; it is pliable and easily worked back. When examined, September 6, 1905, the surface of the compound was full of fine cracks, but the material adhered strongly to the concrete. Webster's elastic cement was continued to be used extensively in wide vertical and horizontal joints and cracks with good results.

MEASURES AGAINST CONDENSATION.

Linings.—The Oregon cedar ceiling, referred to in technical part of annual report of the Chief of Engineers, 1904, page 3717, has shown this

late summer a very small area of fine dry mould on the cedar, at the front of the storeroom, together with a marked dampness on the concrete floor; at a magazine room of this 3-inch Fort H. G. Wright battery, where the front half of the ceiling is Oregon cedar and the other half white pine, dry mould appeared at the sapwood of the pine, but none at all on the cedar. No dampness on either wood, neither at the porous brick lining at walls, was observed; the concrete floor of the magazine named, near the front of the room, was slightly damp.

Linings made at new batteries at Fort Michie are of porous brick, porous tile, and porous mortar, as described in the annual report, same page, named above. Careful observations here as to condensation were made at frequent times since early April, 1905, by Junior Engineer Hunter. His report records a very general absence of condensation at the linings except at non-porous mortar joints; that condensation on concrete or metal surfaces quickly disappeared when rooms were opened at times of clear and dry weather, and even that such moisture was noticed in one case to disappear over night of good weather, although the battery was tightly closed. In summing up conclusions he places the different linings used in order of effectiveness as:

- Hollow porous tile.
- Porous brick (Infusorial Earth Company's).
- Porous mortar, one-half inch coat.
- Rough-finished concrete.
- Smooth-finished concrete.

At Fort Terry, new batteries of one group have large vertical ventilator-openings, 12 inches diameter at front of rooms, or 12 inches by 18 inches at powder passage, and good porous brick linings. At another group the brick of linings are not so good and the ventilation not so free. From reports of observations at time to time by Junior Engineer F. W. LaForge, it appears that while dampness from condensation is very small throughout, the rooms of the first group are on the whole, but not entirely, somewhat freer from it than those of the second group.

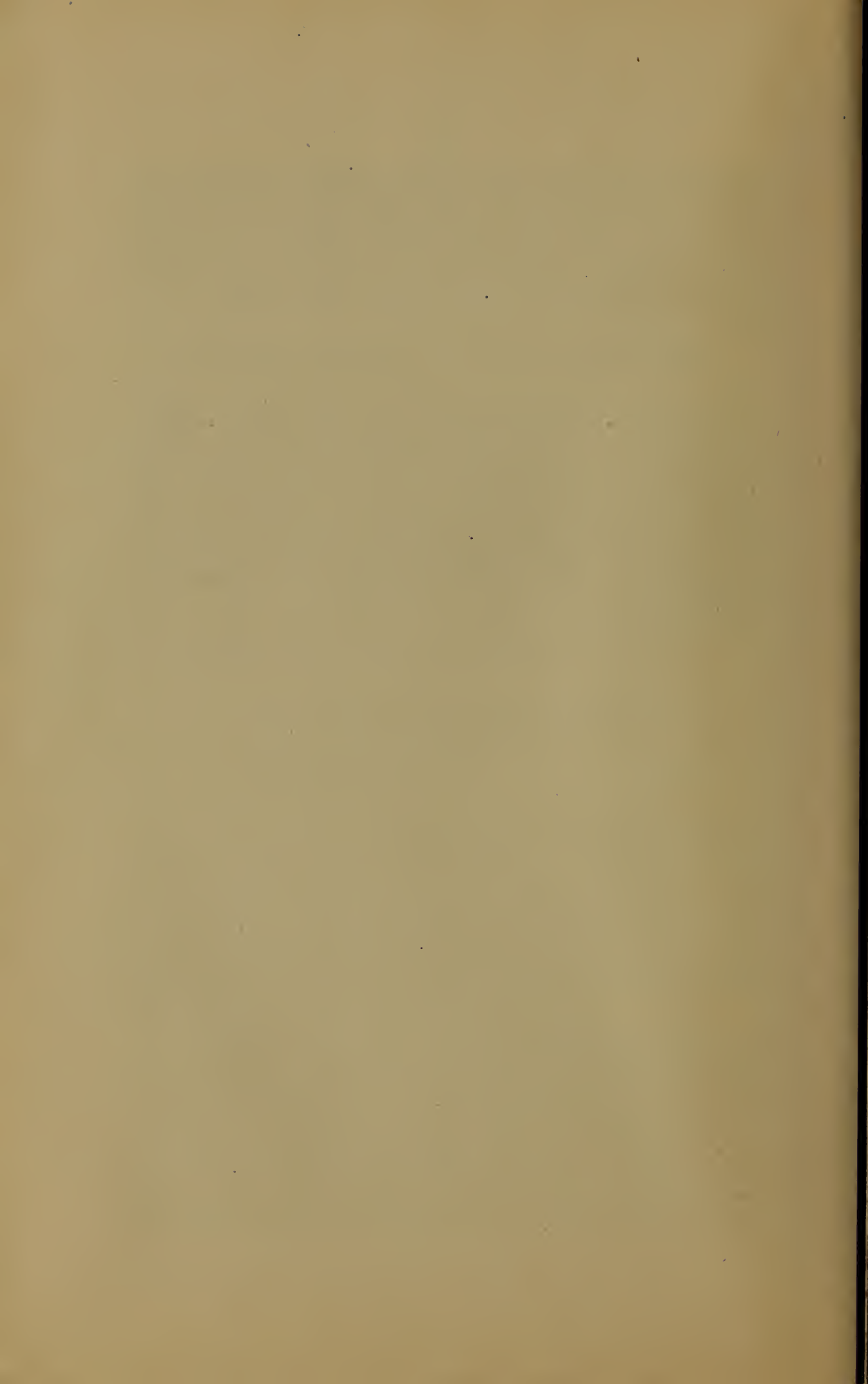
Fan Circulation of Hot Air.—Subsequent to the application of this means of reducing or preventing condensation at emplacement rooms, described in annual report of the Chief of Engineers, 1904, page 2713, the second battery there noted was thoroughly dried and heated by this method and in late September, 1904. Previous to its first hot-air treatment, this battery had shown prolific condensation. Another battery, adjacent, of the same type and built about the same time, was much more dry in 1904 than the one denominated as the second battery. During

the past condensation season, however, the comparative results as to condensation at these two batteries have been reversed, so that the much drier battery this year was the one which had been so thoroughly dried and heated last year. That this continuation for several months of a decided amelioration of condensation was caused by three applications of two hours each of the hot-air treatment seems a fair conclusion.

CONCRETE FEATURES AT A TORPEDO STOREHOUSE.

This structure is of red brick, about 32 feet wide by 195 feet long and two stories high. It was first thought to use granite trimmings, but the cost of the stone, even in this location of granite quarries, was considered too high and recourse was had to concrete for lintels, sills, and water-table. This construction proved so satisfactory that concrete corners were added, and, later, a concrete cornice was built in place instead of a wooden one, at the suggestion of Assistant Engineer G. W. Freeman. Such cornice strengthens the roof truss, is fireproof, and improves the appearance of the building.

* * * * *



CORRESPONDENCE ABOUT CEDAR LININGS OF MAGAZINES IN PUGET SOUND DISTRICT.

(Officers in charge, Maj. John Millis and Lieut. F. A. Pope, Corps of Engineers.)

UNITED STATES ENGINEER OFFICE,
SEATTLE, WASH., *February 10, 1905*

Brig. Gen. A. MACKENZIE,
Chief of Engineers, U. S. A., Washington, D. C.

GENERAL:

I have the honor to request to be advised as early as may be practicable of the conclusions of the Board on percolation and dampness in magazines of defensive works so far as same may be applicable to this district.

Very respectfully, your obedient servant,

JOHN MILLIS,
Major, Corps of Engineers, U. S. A.

[1st Indorsement.]

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
WASHINGTON, *February 20, 1905.*

Respectfully referred to Lieut. Col. C. F. Powell, Corps of Engineers, with request for an early rendition of this most important report, in order that the best application of funds under the pending fortification bill may be made by this office.

* * * * *

By command of Brig. Gen. MACKENZIE:

FREDERIC V. ABBOT,
Major, Corps of Engineers.

[2d Indorsement.]

U. S. ENGINEER OFFICE,
NEW LONDON, CONN., *March 3, 1905.*

Respectfully returned to the Chief of Engineers, U. S. A.

The report may be expected on or very shortly after the 25th inst.

It may be remarked that condensation at the Puget Sound district is little and can be prevented by small ventilation or heating from oil or other stoves at suitable times. Some of the emplacement rooms there

are, however, quite damp from leakage and require treatment at the exterior or room linings.

* * * * *

I suggest that this method be tried as early as practicable at the Puget Sound district, where cedar is readily obtained at moderate cost, and for the special purpose of aiding to determine the least thickness of cedar needed for supporting the sheet copper between bolts and making a rigid enough structure to stand the ordinary service.

* * * * *

CHAS. F. POWELL,
Lieut. Col., Corps of Engineers.

[3d Indorsement.]

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
WASHINGTON, *March 8, 1905.*

Respectfully returned to Major Millis, inviting attention to the preceding indorsement.

Two rooms should be lined at once as suggested, accurate account being kept of actual costs.

* * * * *

To be returned with report of costs as soon as the work is completed. In the report enough details should be given as to how superintendence, contingencies, etc., are computed, and what rates of pay are used, to make it possible for other officers to make reliable local estimates.

By command of Brig. Gen. MACKENZIE:

FREDERIC V. ABBOT,
Major, Corps of Engineers.

[4th Indorsement.]

U. S. ENGINEER OFFICE,
SEATTLE, WASH., *March 1, 1906.*

Respectfully returned to the Chief of Engineers, U. S. A.

Two magazines, one in emplacement No. 1 and one in emplacement No. 3, have been lined at a cost of \$2,215.02, and payment has been made from the allotment of June 21 and July 5, 1904, act of April 21, 1904, from the appropriation for Preservation and Repair of Fortifications.

A tracing showing method of lining the magazines and a report in detail of the cost are sent herewith.

F. A. POPE,
1st Lieut., Corps of Engineers.

STATEMENT OF COST OF LINING POWDER MAGAZINES WITH
COPPER AND CEDAR IN 10-INCH EMPLACEMENTS AT FORT
CASEY, WASHINGTON.

The two most leaky magazines were selected for treatment. The following remarks show condition of the magazines before lining.

Emplacement No. 1:

Jan. 23, 1904—General leaks all over roof, one-fourth inch water on floor in places. Leak around speaking tube.

Mar. 9, 1904—Floor wet. Dropping from ceiling. Doors open.

Nov. 22, 1904—Leaking.

Mar. 25, 1905—Roof leaks; puddle on floor; leak at speaking tube.

May 23, 1905—Leaking badly south half ceiling and over doorway.

Emplacement No. 3:

Jan. 23, 1904—Pretty dry; condensation on roof and door.

Mar. 9, 1904—Dry and nice; doors open.

Nov. 22, 1904—Leaking.

Mar. 25, 1905—Leaky roof near door.

May 23, 1905—Ceiling leaking; also over doorway.

These examinations were made after heavy continuous rains of some 24 hours duration.

No leaks have appeared to date through the new lining.

The magazines are 13 feet 6 inches by 20 feet 6 inches, 8 feet high, and were built by contract in 1897-98.

The drainage chamber is now ventilated by three openings, each 24 inches by 24 inches through the interior walls. Room ventilation is given by apertures which have been cut in the iron doors controlled by shutters.

Ventilation was entirely ignored in original construction.

The best material obtainable has been used, placed by skilful men and no pains spared to make the job as nearly as possible perfect in all respects. It was done by day labor; commenced latter part of May, 1905, and finished early part of January, 1906. Owing to exigencies of other requirements and some waits for material, it was not practicable to prosecute the work uninterruptedly.

It was not at first designed to line the head-room over the door passage, but this was later found necessary, which has added somewhat to the cost.

ITEMIZED STATEMENT OF COST.

Superintendence:

Proportionate salary Junior Engineer.....	\$16.50	
Proportionate salary Inspector, work and material	46.88	
Transportation of Engineer and Inspector	4.00	
		\$67.38
Amount carried over		
		\$67.38

ITEMIZED STATEMENT OF COST—*Continued.*

Amount brought forward		\$67.38
<i>Plans:</i>		
Office work, Draftsman	\$40.57	
Material	.50	
		41.07
<i>Cutting and Drilling Concrete</i> (Cutting out 110 cubic feet concrete and drilling 300 holes 1 inch by 4 inches deep):		
Laborers, at \$2.00 per day	\$220.00	
Blacksmith at \$3.00 per day	8.17	
Tool steel, 132 lbs.	9.67	
		237.84
<i>Finishing Concrete:</i>		
Cement Worker at \$4.00 per day	\$69.76	
Cement, 4 bbls., at \$3.00 per bbl.	12.00	
		81.76
<i>Drain Pipes:</i>		
Cutting and placing; pipe fitters, at \$3.00 per day	\$20.44	
13 feet of 3-inch and 50 feet of 2-inch galv. wrought-iron pipe and fittings	15.00	
		35.44
<i>Hardware:</i>		
Brass bolts, sleeves and washers, per detail	\$274.54	
Galv. iron anchors	56.80	
Lead washers	12.00	
Galv. lag screws with galv. expansion shields	12.60	
50 lbs. galv. cut nails	3.00	
79 lbs. common iron	1.88	
Labor placing hardware, etc.	118.45	
		479.27
<i>Copper Work:</i>		
2,263 lbs. 16 oz. cold rolled sheet copper, 36 inches by 96 inches, at 22½ cents per lb.	\$509.17	
40 lbs. solder at 20 cents per lb.	8.00	
10 gals. gasoline	2.43	
1 qt. muriatic acid	.10	
1 doz. hack-saw blades	.60	
Coppersmith at \$4.00 per day	233.15	
		753.45
<i>Waterproofing:</i>		
1,200 lbs. tar pitch at 1 cent per lb.	\$12.00	
Laborers, at \$2.00 per day	22.25	
		34.25
<i>Woodwork:</i>		
6,792 lin. ft. ½-inch by 3-inch clear cedar.		
512 lin. ft. ½-inch by 2-inch clear cedar.		
336 lin. ft. 1-inch by 2-inch clear cedar.		
16 lin. ft. 4-inch by 6-inch clear cedar.		
7,656 lin. ft. clear cedar at 14 cents per foot	\$108.24	
Amount carried over	\$108.24	\$1,730.46

ITEMIZED STATEMENT OF COST—*Continued.**Woodwork—Continued:*

Amount brought forward	\$108.24	\$1,730.46
256 lin. ft. ½-inch by 2-inch clear spruce.		
168 lin. ft. 1-inch by 2-inch clear spruce.		
16 lin. ft. 4-inch by 6-inch clear spruce.		
440 lin. ft. clear spruce at 15 cents per foot	6.60	
Carpenters, at \$3.00 per day	121.17	
		236.01

Painting:

Material, 3 coats white paint	\$2.00	
Painter at \$3.20 per day	28.50	
		30.50

Gratings:

35 lbs. common iron	\$1.40	
Blacksmith at \$3.00 per day	3.00	
Laborers, setting, at \$2.00 per day	8.14	
		12.54

Cast Ventilators:

6 standard frames and doors, at \$13.33⅓	\$80.00	
6 padlocks, at \$1.00	6.00	
Laborers, setting, at \$2.00 per day	28.68	
		114.68

Door Ventilators:

Material	\$0.80	
Blacksmith at \$3.00 and helper at \$2.00	48.87	
		49.67

Electric Wire Pipes:

Pipe fitters, at \$3.00 per day		9.98
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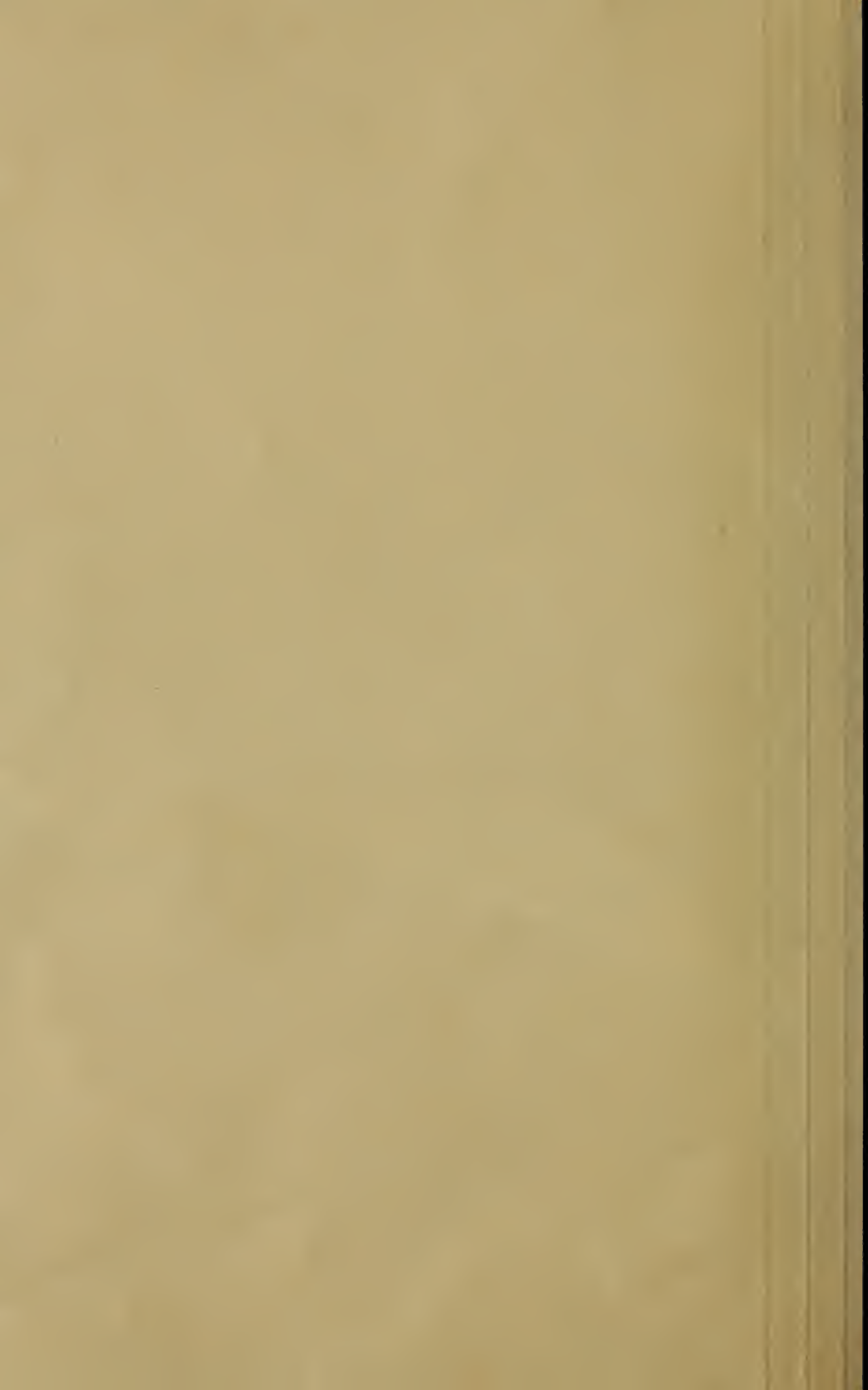
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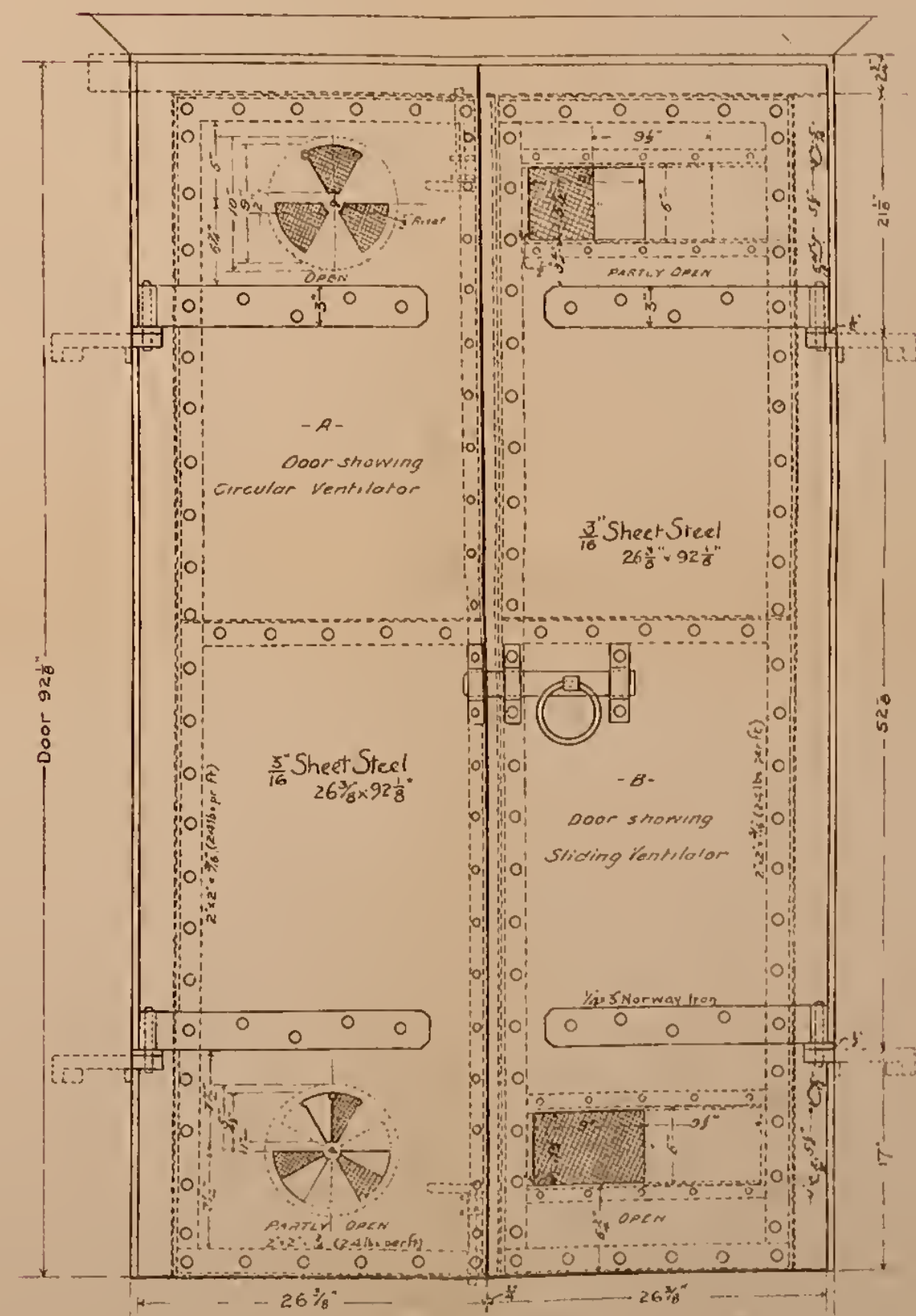
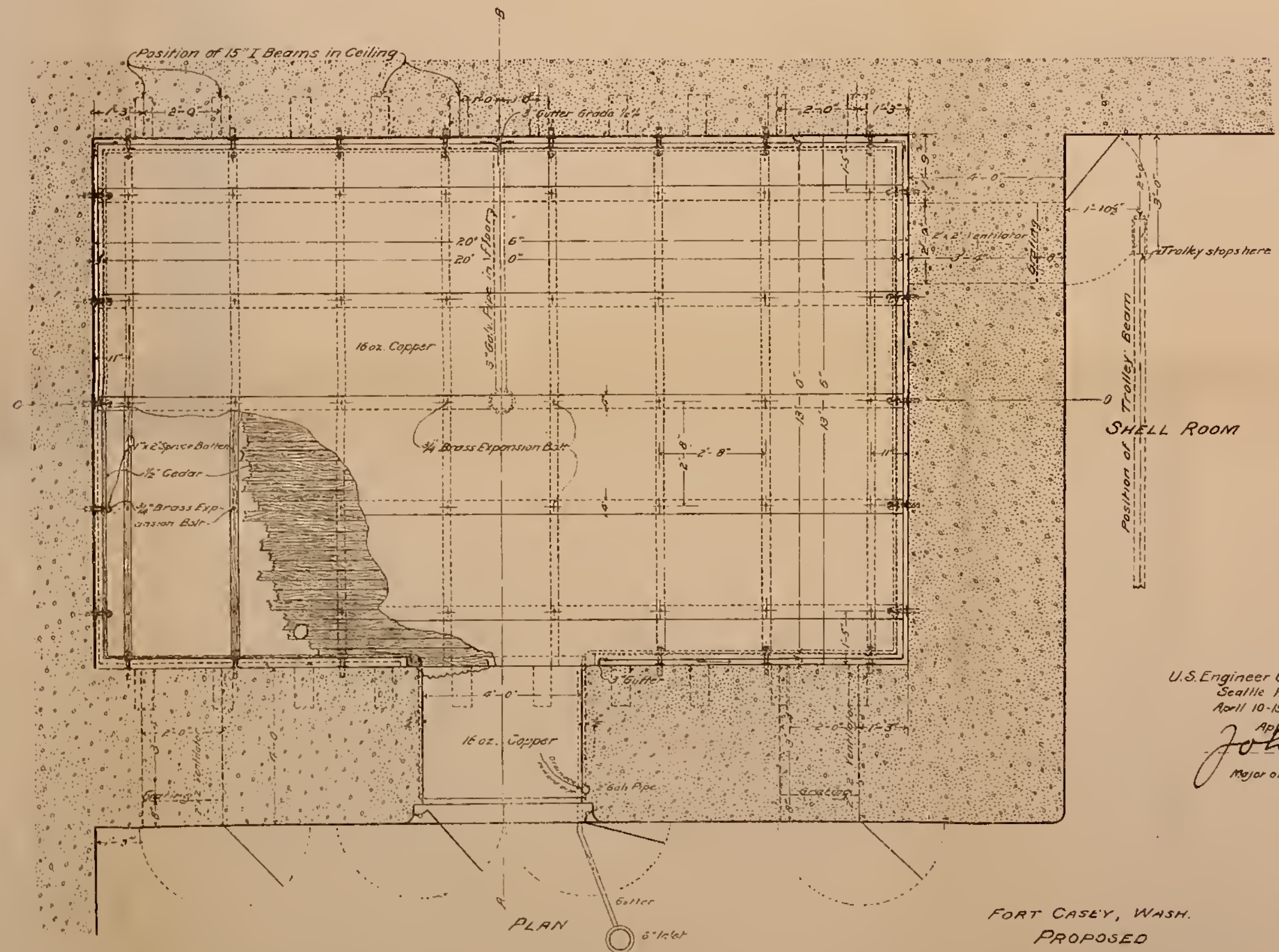
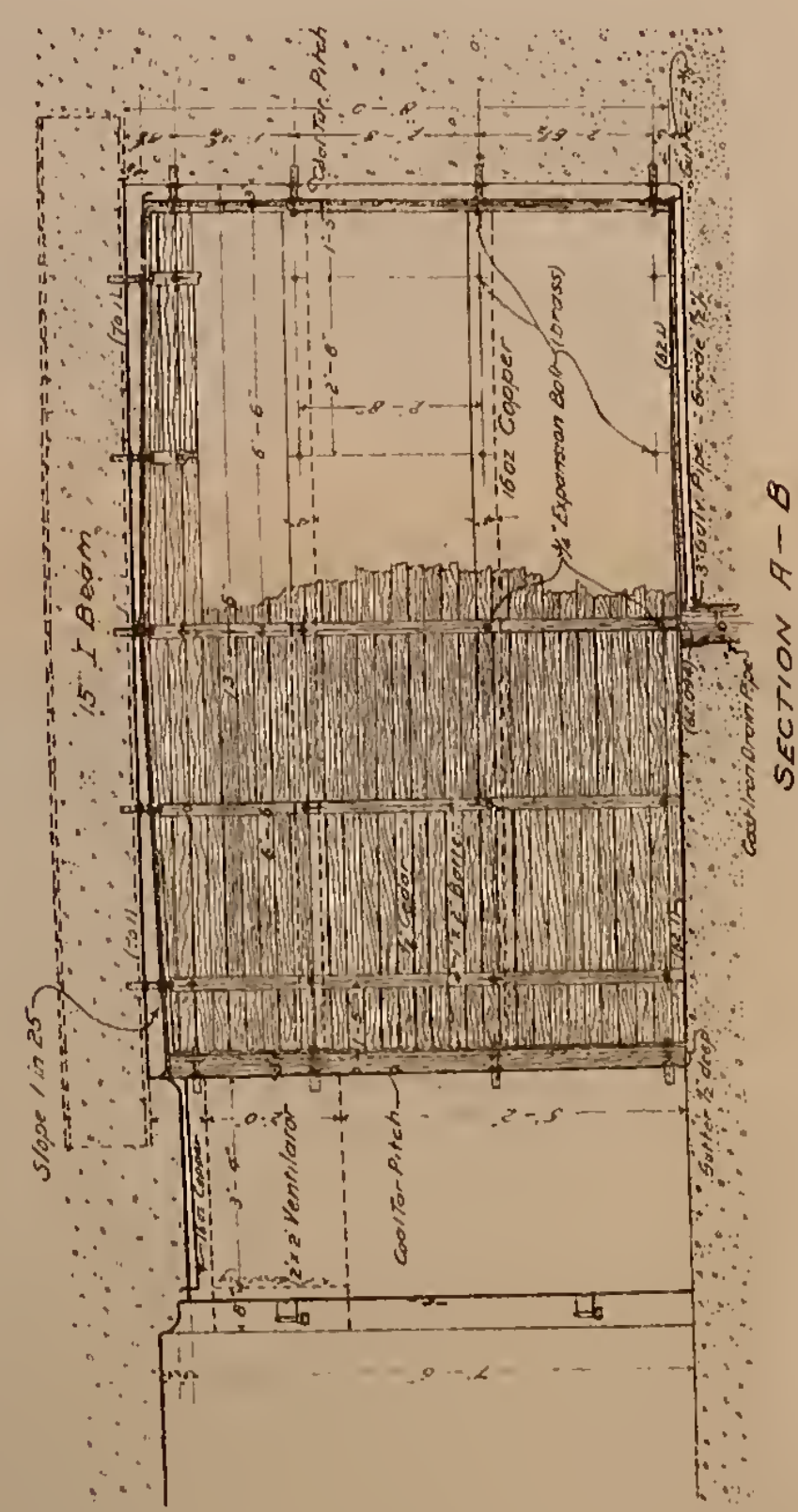
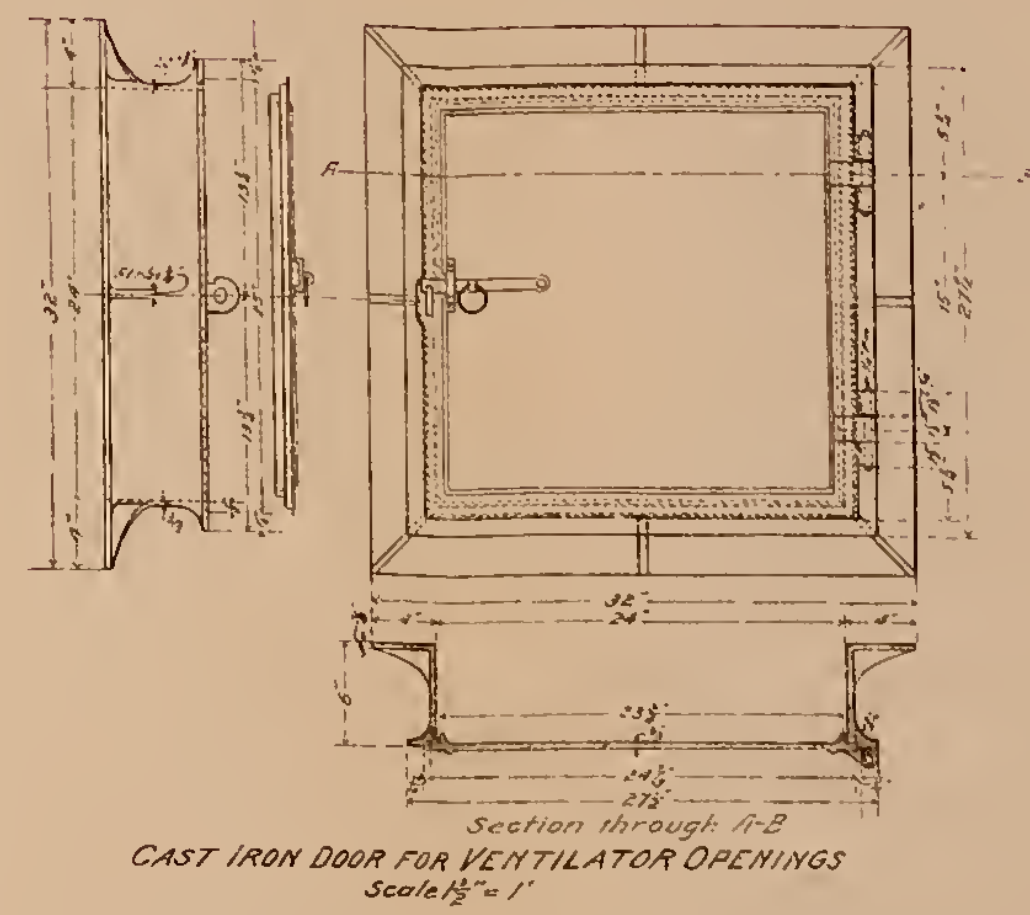
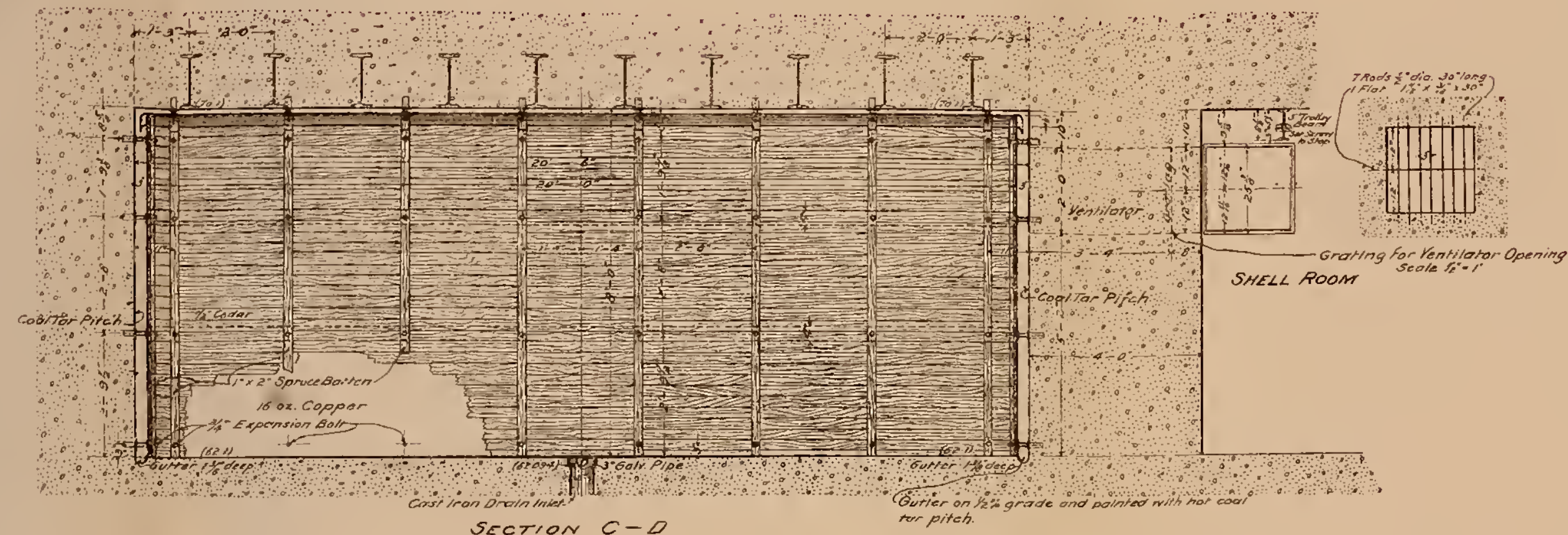
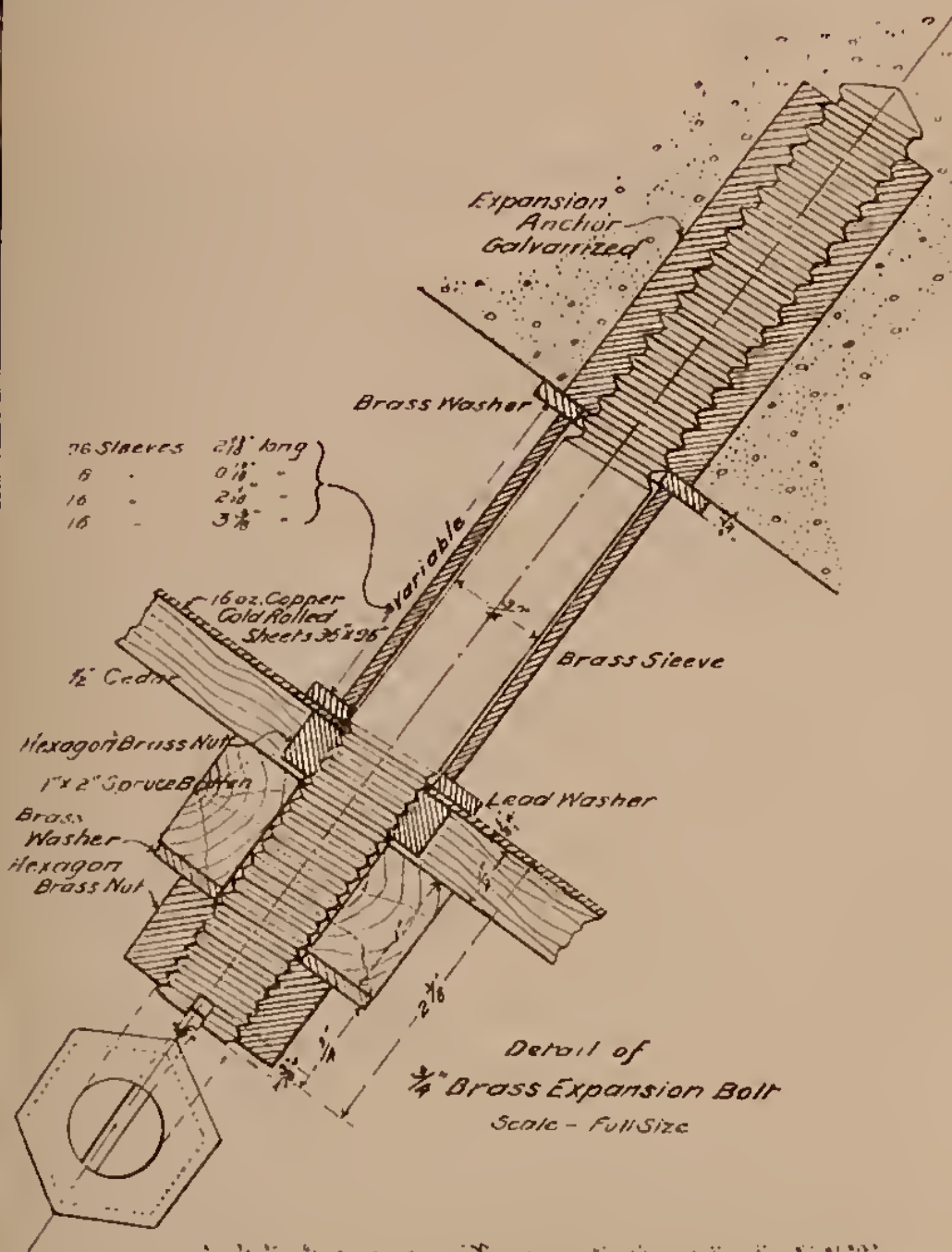
Kerosene	\$3.00	
Coal	2.00	
Glass for lanterns	.30	
Sundry labor, cleaning up, team, etc.	25.88	
		31.18

Total cost for two magazines	\$2,215.02
Average for one magazine	1,107.51









U.S. Engineer Office
Seattle Wash.
March 10, 1905

Approved by the Chief of Engineers
M. G. H. S. P.
Major of Engineers, U.S. Army

March 10, 1905.

FORT CASEY, WASH.
PROPOSED
LINING FOR MAGAZINES, 10" BATTERY
EMPLACEMENTS 183
Scale 1/2" = 1'

U.S. Engineer Office
Seattle Wash.
April 10, 1905
Approved
Johnnie
Major of Engineers, U.S. Army

J. D. Mason
Junior Engineer

NOTE: Style A Ventilator adapted and placed in right hand leaf of doors.



RIVER AND HARBOR WORK IN DETROIT DISTRICT.

(Officer in charge, Colonel Chas. E. L. B. Davis, Corps of Engineers.)

THE BATHOMETER.

The bathometer described below was used in making the survey for the 22 and 25-foot channel from the lower end of Lake Huron to the upper end of the Detroit River.

It was invented and developed by Mr. E. S. Wheeler, chief assistant engineer, and proved itself to be a very efficient sounding apparatus, particularly as it gives a continuous profile of the river or lake bottom on a paper disk by means of a self-recording apparatus.

A careful study of the records through Lake St. Clair showed an enlargement of the channel, which has probably taken place within the last ten years. Between 1894 and 1897 this channel was dredged to 20 feet throughout its length, with the exception of about 2 miles, the total amount of material removed being about one and a half million cubic yards. The records showed that the dredged channel had been much widened and deepened, the portion where no dredging was done showing a well-marked channel. The total amount of material removed has been about three and a half million cubic yards, or two million more than had been dredged. The cross-sections show an irregular bottom from 800 to 1,500 feet wide, following the sailing line from the lower end of the canal to the upper end of Grosse Point cut. This enlargement is undoubtedly due to the action of propellers of deep draft steamers. Before 1896 the maximum draft that could be carried through the locks at Sault Ste. Marie, Mich., was about 15 feet, not deep enough to have much effect on the bottom of Lake St. Clair, where the normal depth was about 19 feet. In August, 1896, the Poe Lock was opened to commerce, which, with other improvements, increased the possible draft about 3 feet and brought the propellers of the heavily loaded steamers close to the bottom of Lake St. Clair, and it is probable that the enlargement began about this time and has continued at the rate of about 200,000 cubic yards annually.

While the existence of this channel would have been revealed by the ordinary sounding-lead, its boundaries would not have been so sharply defined, and much closer soundings would have been necessary to have made as close estimates of the amount of material removed.

The instrument has certainly many obvious advantages and applications, and Mr. Wheeler will continue to perfect it.

REPORT OF MR. E. S. WHEELER.

The apparatus is called a "Bathometer." In its construction use has been made of the following principle:

If air be forced through a tube the lower end of which is submerged in water, then the pressure of the air at the upper end will equal the pressure of the water at the lower end plus the pressure due to the frictional resistance of the air passing through the tube. If then the pressure of the air at the upper end of the tube and the frictional resistance are known, the pressure of the water at the lower end becomes known, and since the depth of water is a known function of the pressure, the depth is known.

The essential parts of this bathometer are: *First*. A flexible tube weighted at one end so that it can be submerged, and branched at the other end so that an air pump and a pressure gage or register can be attached. *Second*. An air tank and pump capable of forcing a continuous stream of air through the tube and out at its lower or submerged end. *Third*. A pressure gage that will measure separately the pressure due to the friction of the air passing through the tube, and the water pressure at the lower or submerged end. *Fourth*. A register that will record automatically and continuously the pressure at the upper end of the tube (expressed in feet) due to the depth of the submerged end. Plate 1 shows the apparatus with the parts assembled as they were used on the U. S. S. *Hancock*. The tube or sounding line is shown at G, Plate 1. It is made of a tube one-half inch in diameter with a bore of one-fourth inch. The tube is protected by a woven cotton covering, the warp of which is longitudinal or parallel to the rubber tube; this prevents excessive stretching and collapsing that might be the case if the warp was woven in a spiral around the rubber tube. The line used was four-ply, or had four concentric coverings of cotton dipped in a preservative mixture, which gave the line a tensile strength of a little more than 1,000 pounds, and an exterior diameter of 0.85 of an inch. A cross-section is shown at Plate 1, R. Outside of the cotton there is a metal armor which serves the double purpose of weighting the submerged end and protecting the line from wear, as shown at H. The metal armor is made of short pieces of pipe about $1\frac{1}{2}$ inches long and $\frac{1}{4}$ inch thick, which makes the outside diameter 1.35 inches. These short sections of pipe when made of iron are cast and chilled. Between the sections are rubber rings which serve the double purpose of keeping the line more flexible and preventing the

armor from slipping along the line. At the lower or submerged end of the line there is a check-valve which permits the unobstructed outward flow of the air and prevents the water from flowing back into the tube. The line used last season was 190 feet long and about 50 feet of the submerged end was armored with lead; this made a weight of about 130 pounds. The air is first forced into the air tank D, Plate 1. When steam was available, a small Westinghouse air compressor C was used. At other times a hand pump was employed. The air passes from the tank into the register A and A' and through the sounding line G. The register is automatic and is shown in detail on Plates 2 and 3. There is a paper disk or card I which is revolved by clockwork K. The index or pointer carries a fountain pen L, which leaves a continuous line or curve on the disk as it revolves under the pen. The pen is moved by the Bourdon tubes M. Several Bourdon tubes or "tube springs" are attached to one shaft in order to give enough force to move the pen over the surface of the paper disk. The register used last season had eight tube springs.

The adjustments of the apparatus are made as follows: *First*. A suitable scale is marked with circles on the paper disk I. The levers N are then adjusted so that the pen will move a unit on the scale when the submerged end of the sounding line is changed a unit. This adjustment is tested by submerging the sounding line to a known depth and noting that the pen marks a corresponding depth on the scale. This adjustment when properly made is quite permanent. It is, however, not alone necessary that the pen should move over the proper distance, but it should point to the proper graduations on the scale. The second adjustment is to insure this result and may be called the adjustment for index error. When the open end of the sounding line is out of the water and the pen points to the zero of the scale, there is no index error. The three principle sources of index error are change of pressure in the air tank, dimensions of the sounding line, and area of the aperture. The apparatus has therefore been so arranged that while it is in use these three conditions can be kept so nearly constant that there is no appreciable index error. When not in use, the pen usually drops a little below the zero of the scale. The friction of the air in passing through the sounding line when its open end is out of water causes some pressure in the register. If air is admitted to the sounding line and register in exactly the right quantity, this frictional pressure will cause the pen to rise to the zero of the scale. If, now, the orifice between the tank and the register, the pressure in the tank, and the dimensions of the sounding line remain constant, the pen will remain at the zero of the scale, and the apparatus will be in adjustment. These three conditions are kept constant in the following manner: *First*. The

pressure in the air tank is controlled by a governor. *Second.* The orifice between the tank and the register is a small circular hole in a diaphragm which is inserted in the connecting tube. This hole is sometimes jeweled to prevent rust or wear. The size is determined by repeated trials. The dimensions of the sounding line (length and diameter of the bore) are constant unless the line is changed, in which case a new adjustment for index error is made. With ordinary care the index error need not exceed two-tenths of a foot. The methods employed last season in the use of the "bathometer" were as follows: The work was done from the U. S. S. *Hancock*. The depth of water was usually not more than 30 feet. Air was pumped into the tank so as to show a pressure of 70 pounds. All adjustments were carefully made. The sounding line was passed overboard and about 180 feet paid out. The steamer, running at the rate of about 6 miles per hour, dragged the line over the area to be sounded. The register showed a correct cross-section of the bottom, as at P, Fig. 2. The lines of soundings in Lake St. Clair work were located by means of buoys which were placed in two lines, about 3,500 feet apart on either side of the proposed channel; the buoys were located with transit pointings and sextant angles. In the Lake Huron work the steamer was located every five minutes by transit pointings from two shore stations.

When more minute surveys are required, such as making estimates for contract work, etc., more accurate location can be made by any of the usual methods. A specimen of the automatic record is shown at P, Fig. 2. This record was made on August 16, on which date the steamer *Hancock* was sunk by collision in Lake St. Clair. The drawing is an exact copy of the disk that was in the bathometer at the time of the sinking. The long straight line at Q was caused by the shock of the collision. The clock was adjusted so as to cause the disk to make a complete revolution in one hour. During the hour preceding the sinking of the steamer, the channel had been crossed from buoy to buoy five times. The time of passing the buoys is shown by the short straight lines, which are made by the observer giving the bathometer a shake or jar so as to cause the pen to vibrate. During a portion of last season 22 miles of ship channel in Lakes Huron and St. Clair were sounded with a bathometer. The work was done rapidly and with a small working force. The bathometer was used in weather that was much too rough for the ordinary methods. The results were as accurate and satisfactory as those obtained in the ordinary methods.

2KEL

George & John's original

1. 1st floor

2. 2nd floor

3. 3rd floor

4. 4th floor

5. 5th floor

6. 6th floor

7. 7th floor

8. 8th floor

9. 9th floor

10. 10th floor

11. 11th floor

12. 12th floor

13. 13th floor

14. 14th floor

15. 15th floor

16. 16th floor

17. 17th floor

18. 18th floor

19. 19th floor

20. 20th floor

21. 21st floor

22. 22nd floor

23. 23rd floor

24. 24th floor

25. 25th floor

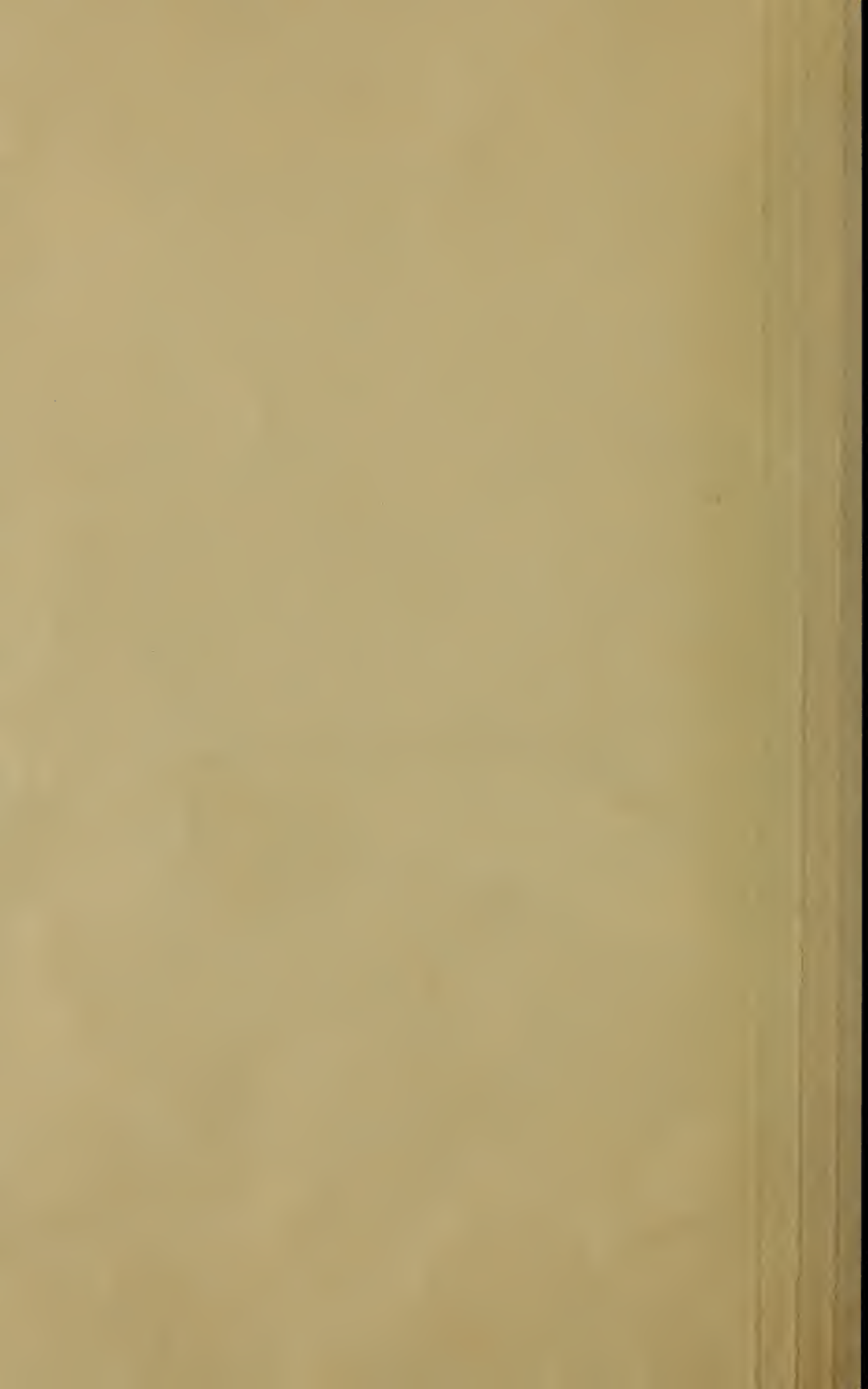
26. 26th floor

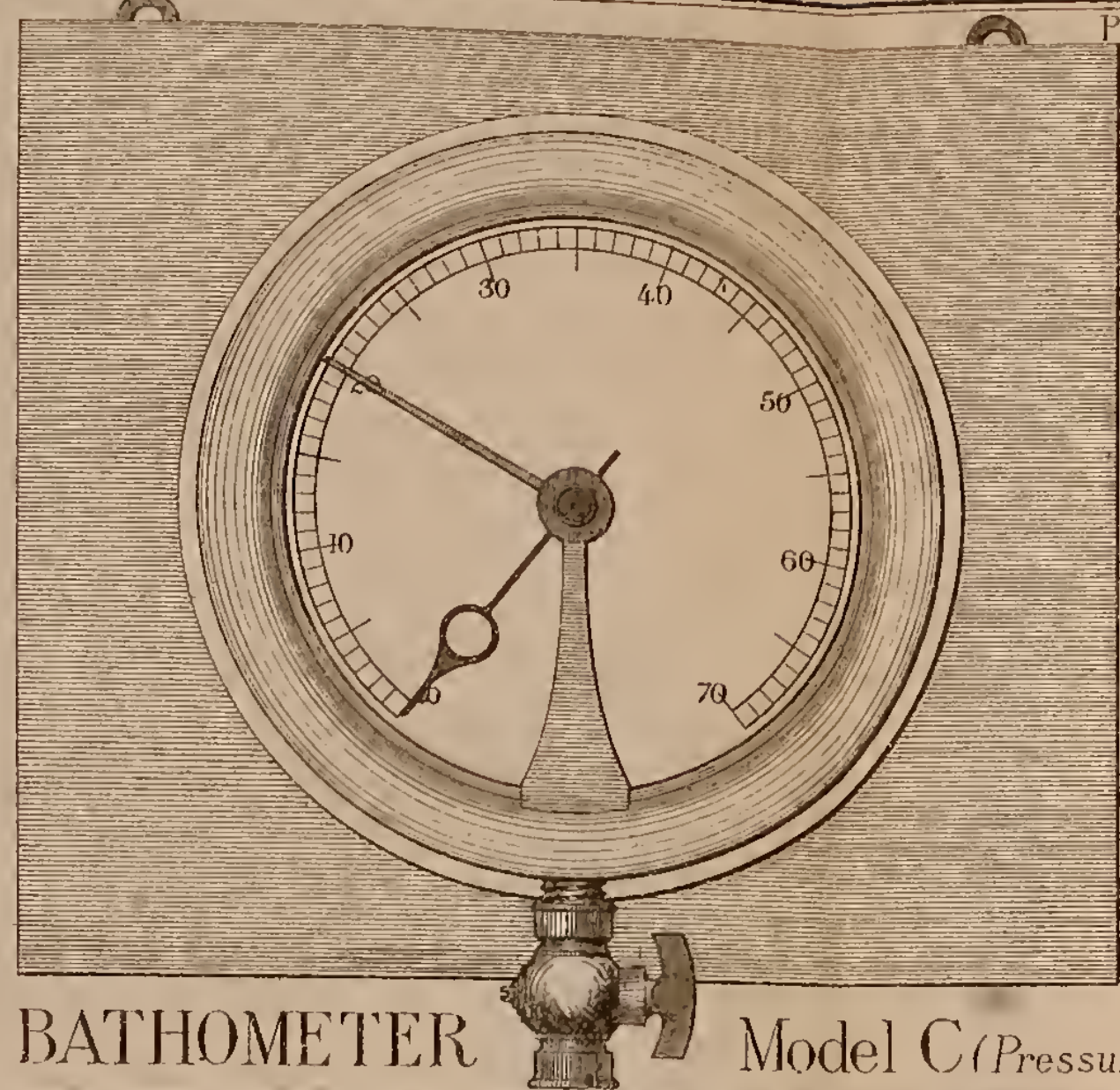
27. 27th floor

28. 28th floor

29. 29th floor

30. 30th floor



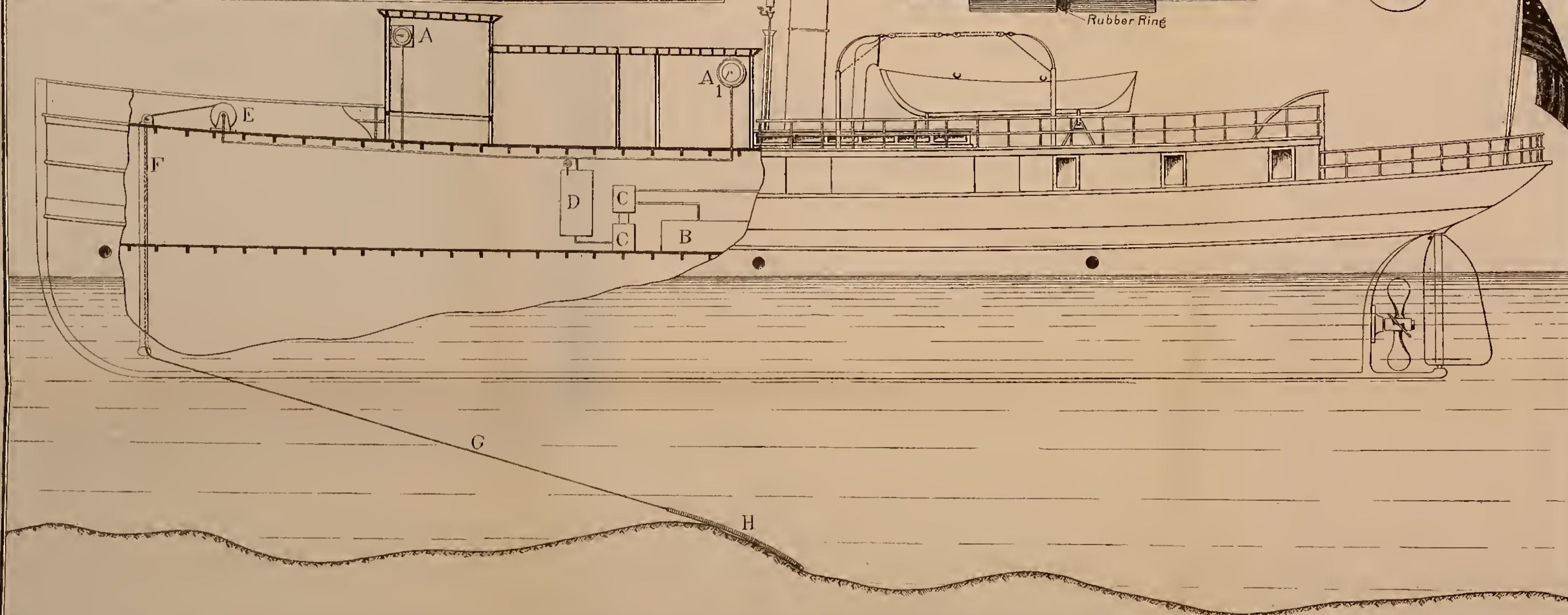
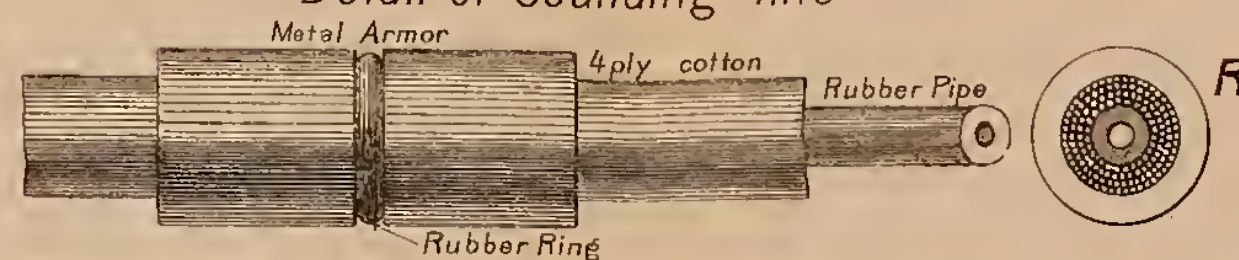


SKETCH

Showing a Steamer equipped with Bathometer.

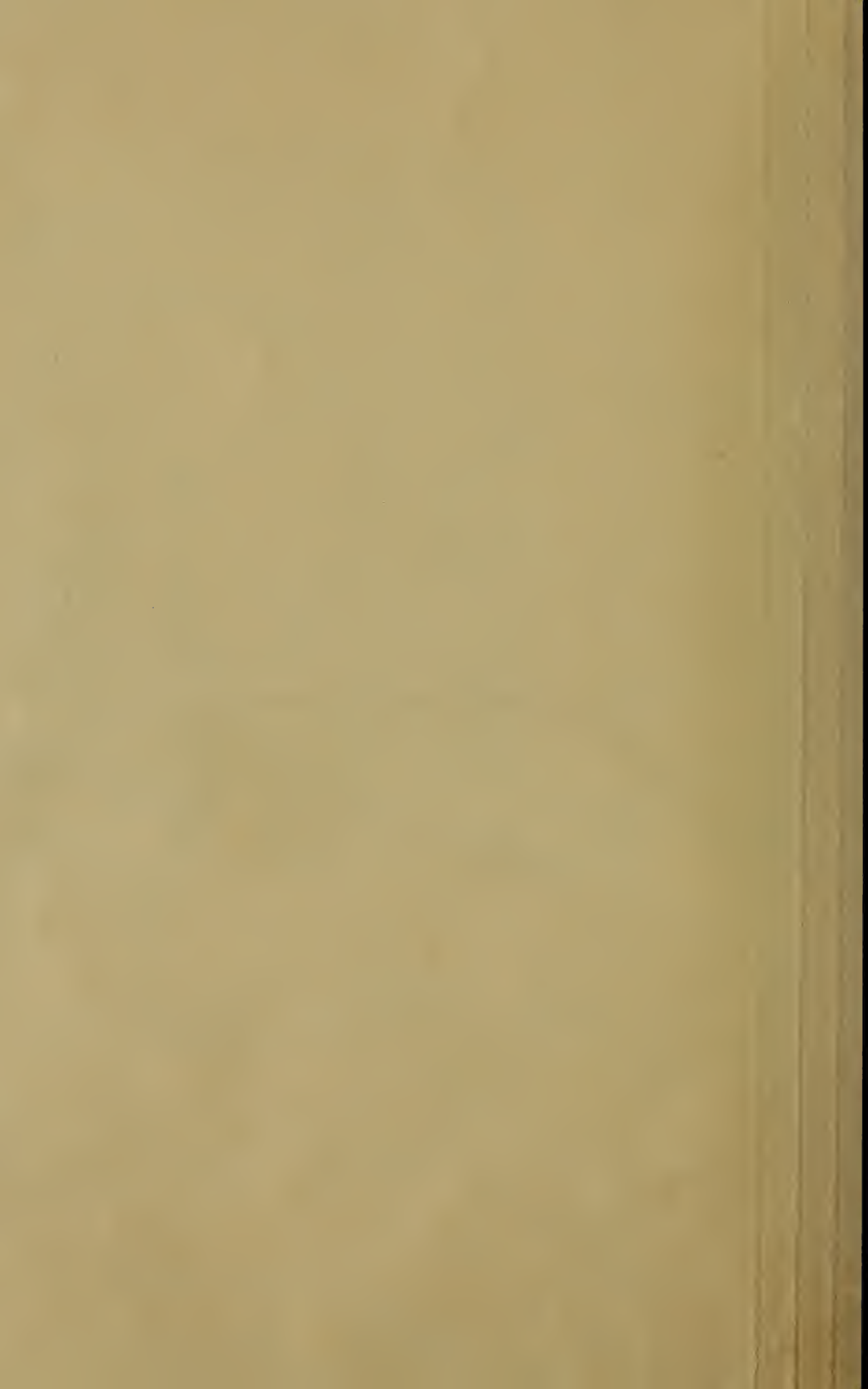
- A, A₁ Registers
- B Boiler
- C Steam-chest and Air-compressor
- D Tank
- E Cable Drum
- F Pipe
- G Sounding-line
- H Sounding-line weighted with metal armor

Detail of Sounding-line









Register for
BATHOMETER,
Model A.

Fig. 1

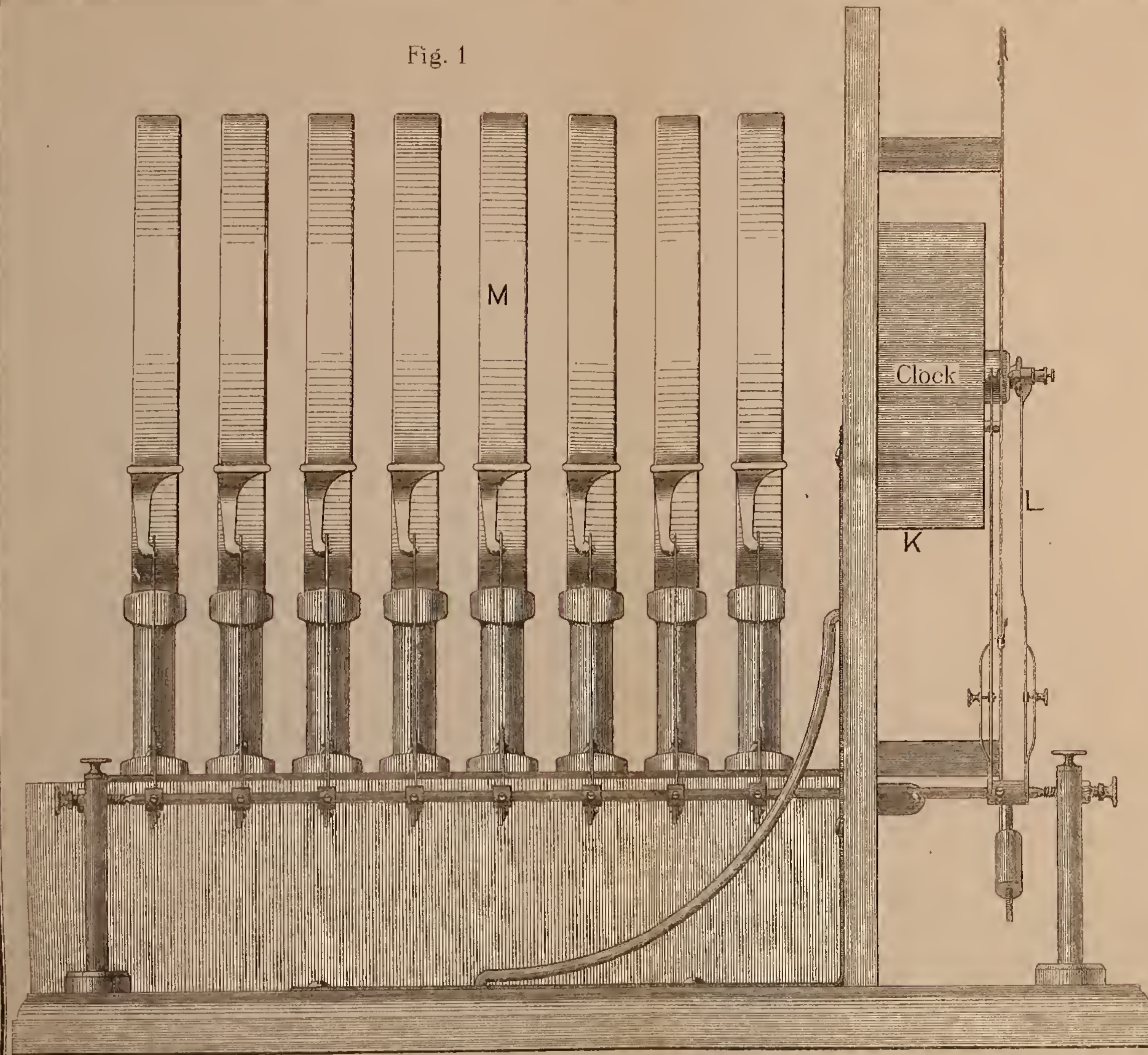


Fig. 2

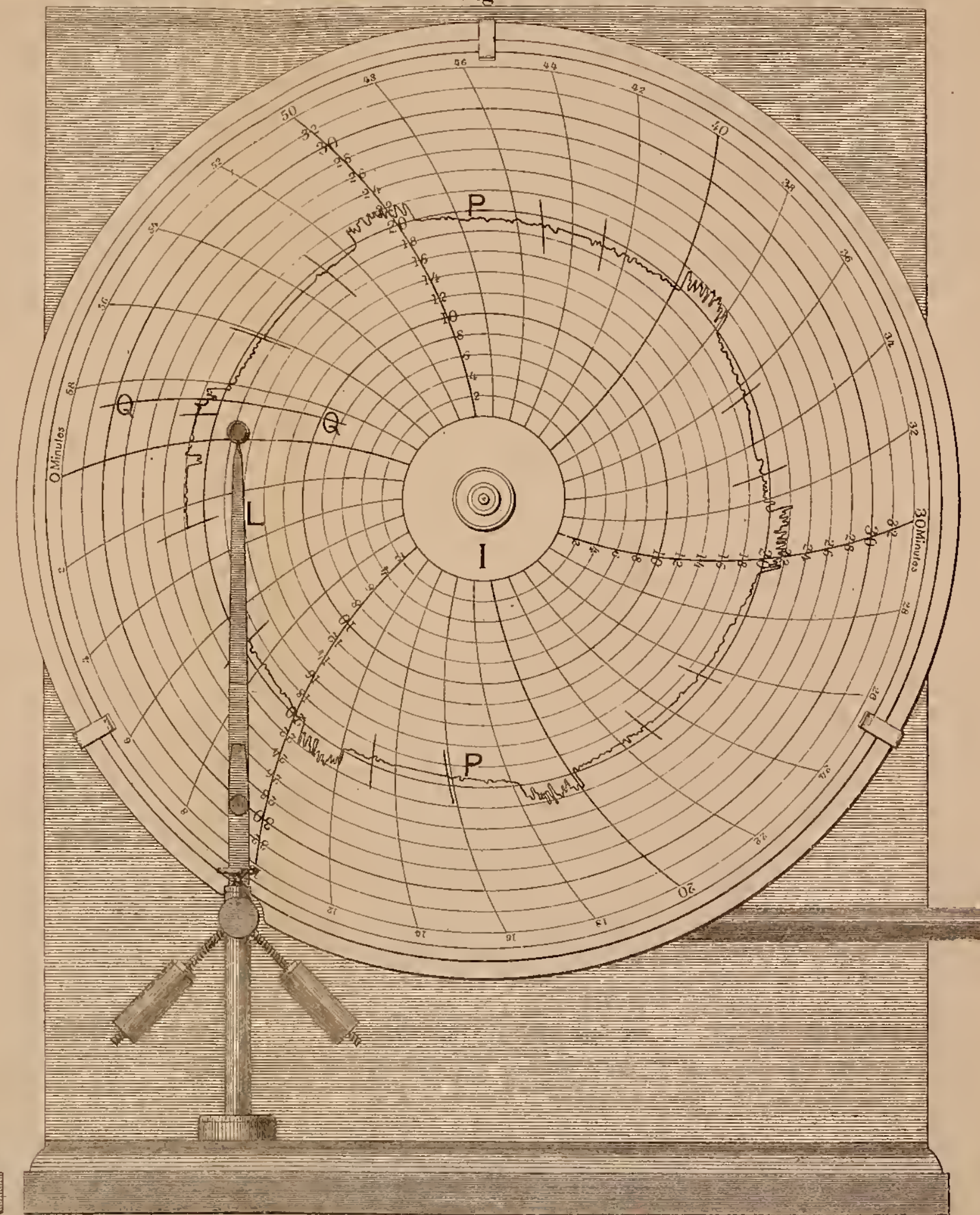
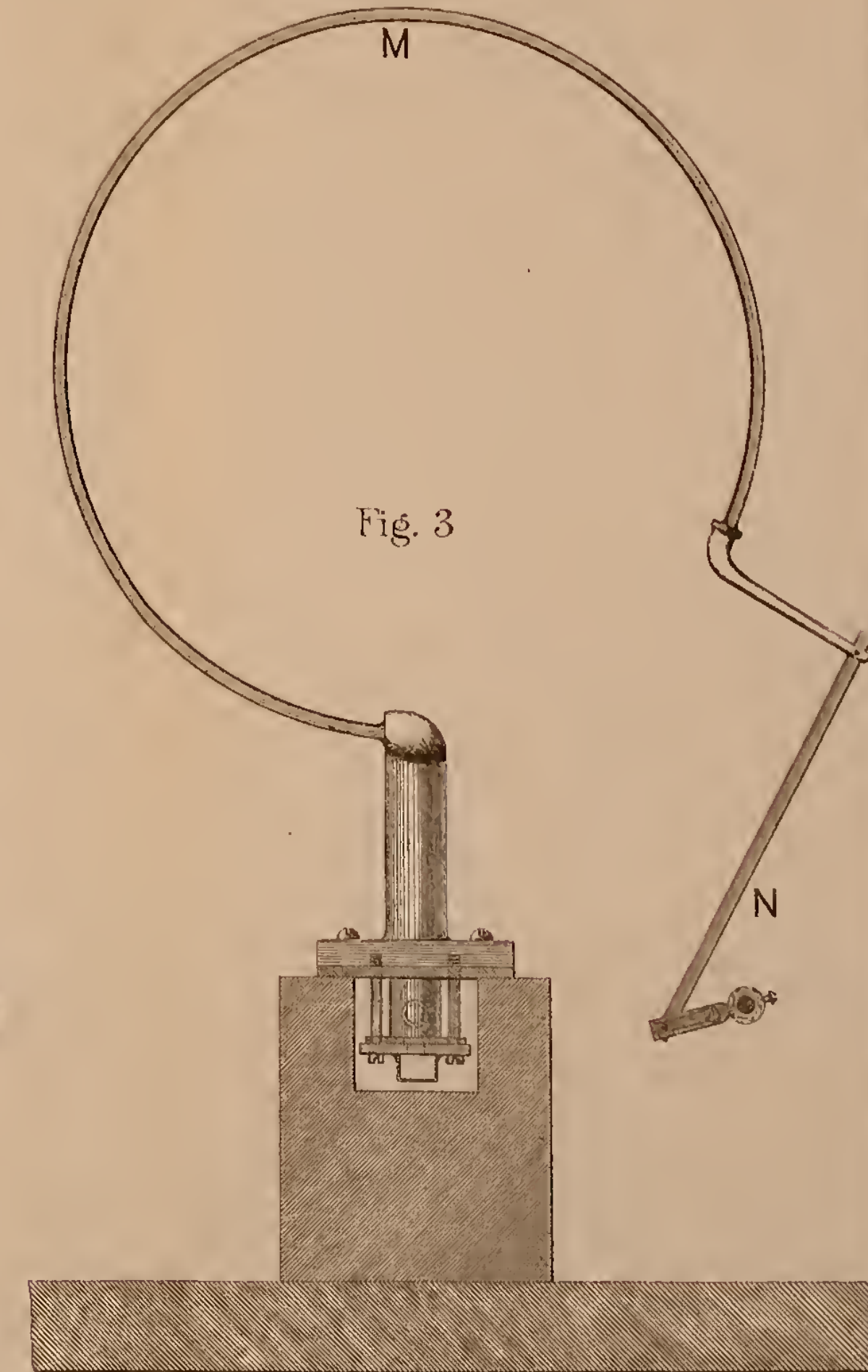
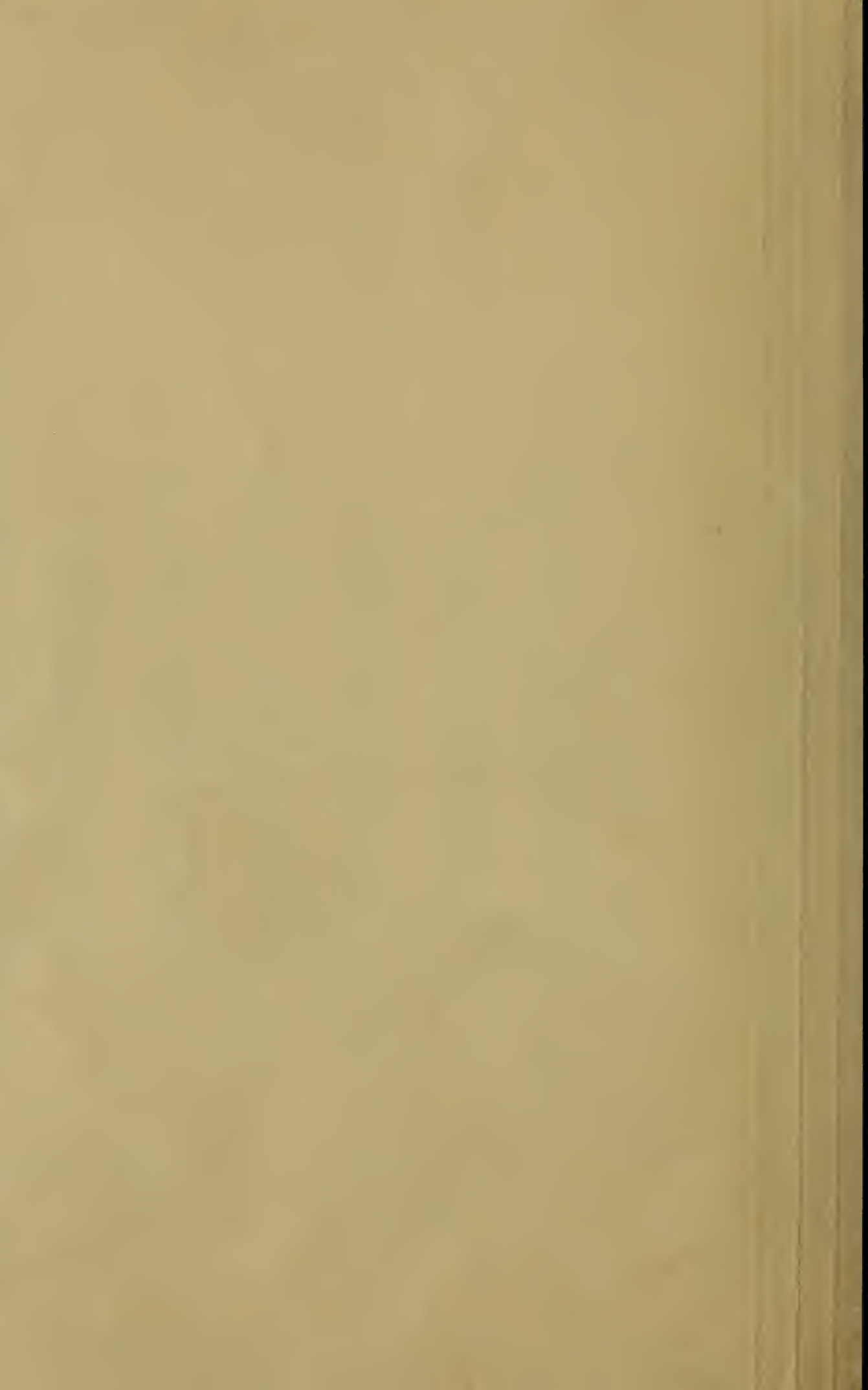


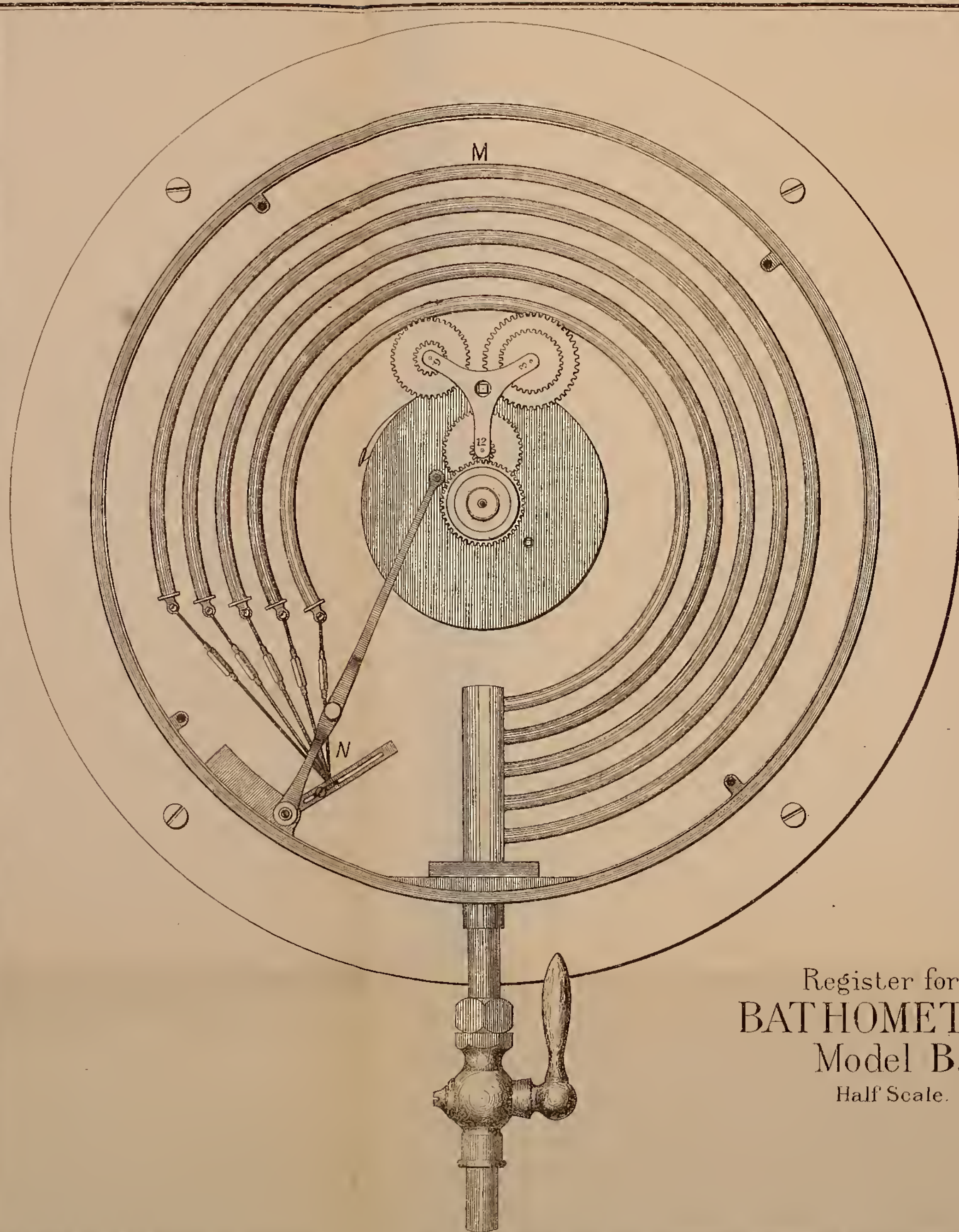
Fig. 3



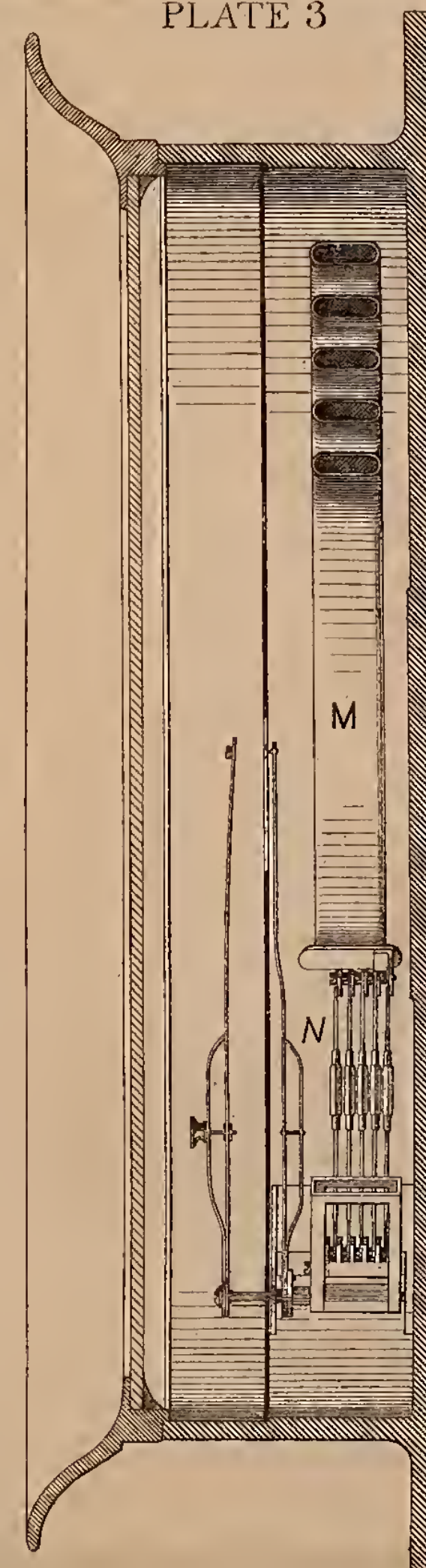








Register for
BATHOMETER,
Model B.
Half Scale.





MAY 22 1907



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